Software Product Lines

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Today’s Talk

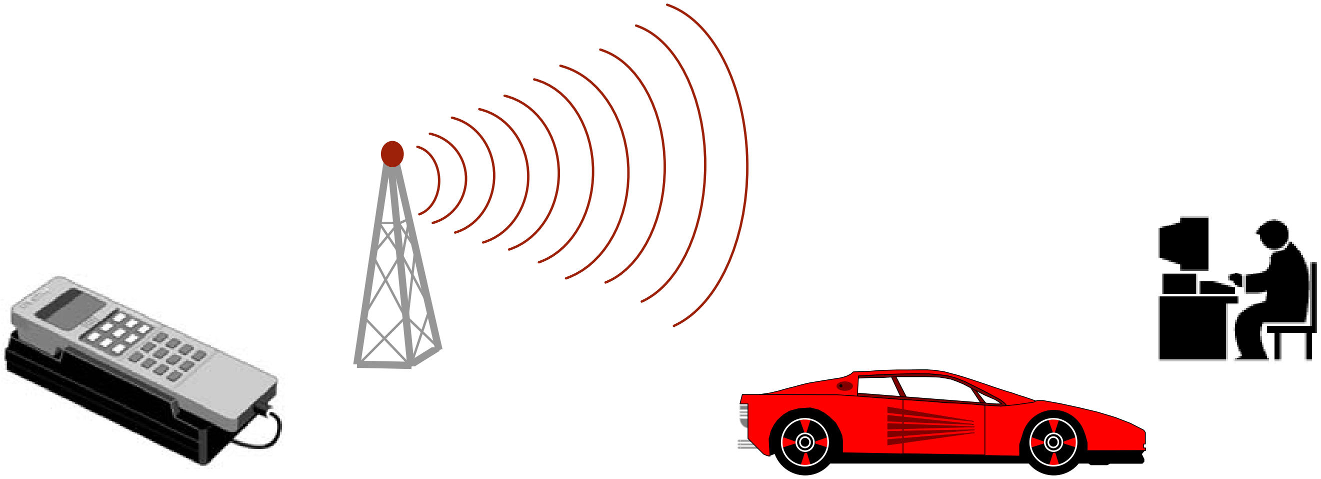
Introduction

Product Line Concepts

- What
- Why
- How

Conclusion

Business Success Requires Software Prowess



Software pervades every sector.

Software has become the bottom line for many organizations who never envisioned themselves in the software business.

Universal Needs

Deploy new products (services) at a rapid pace

Accommodate a growing demand for new product features across a wide spectrum of feature categories

Exploit a rapidly changing technology base

Gain a competitive edge

Universal Business Goals

High quality

Quick time to market

Effective use of limited resources

Product alignment

Low cost production

Low cost maintenance

Mass customization

Mind share

improved efficiency and productivity

The Ultimate Universal Goal

Substantial

Quick

Sustainable

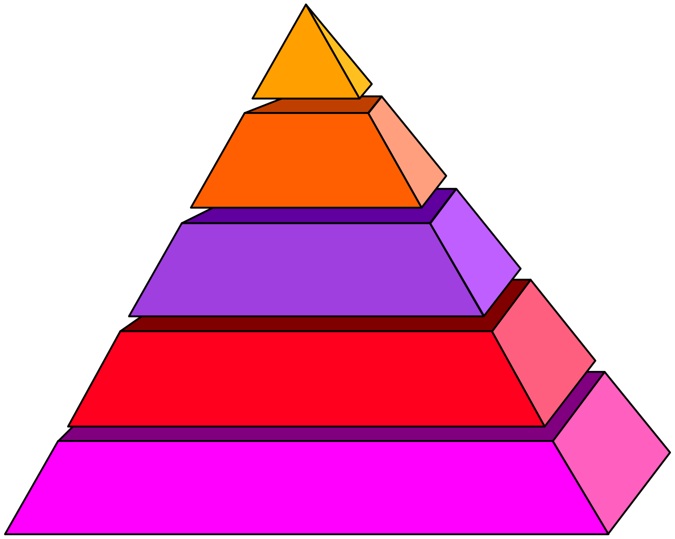
PROFIT

Software (System) Strategies

Process Improvement

Technology Innovation

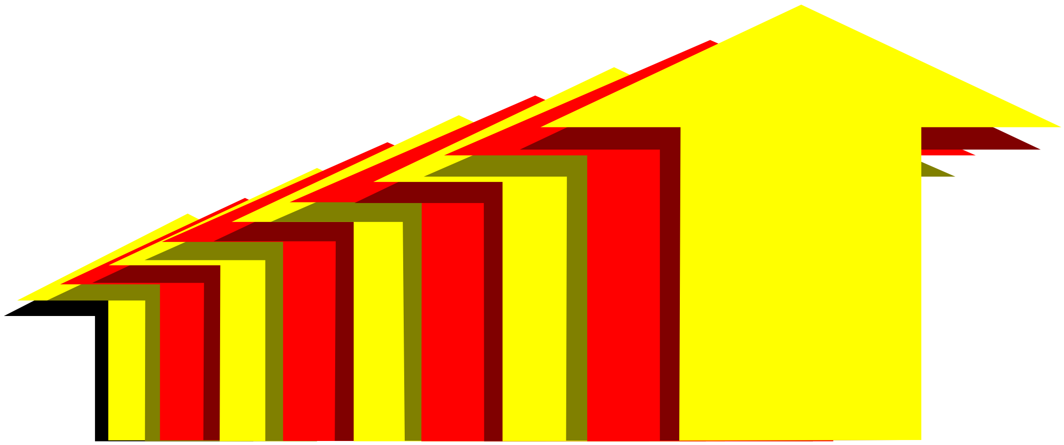
Reuse



Few Systems Are Unique

Most organizations produce families of similar systems, differentiated by features.

Reuse History



1960's
Subroutines

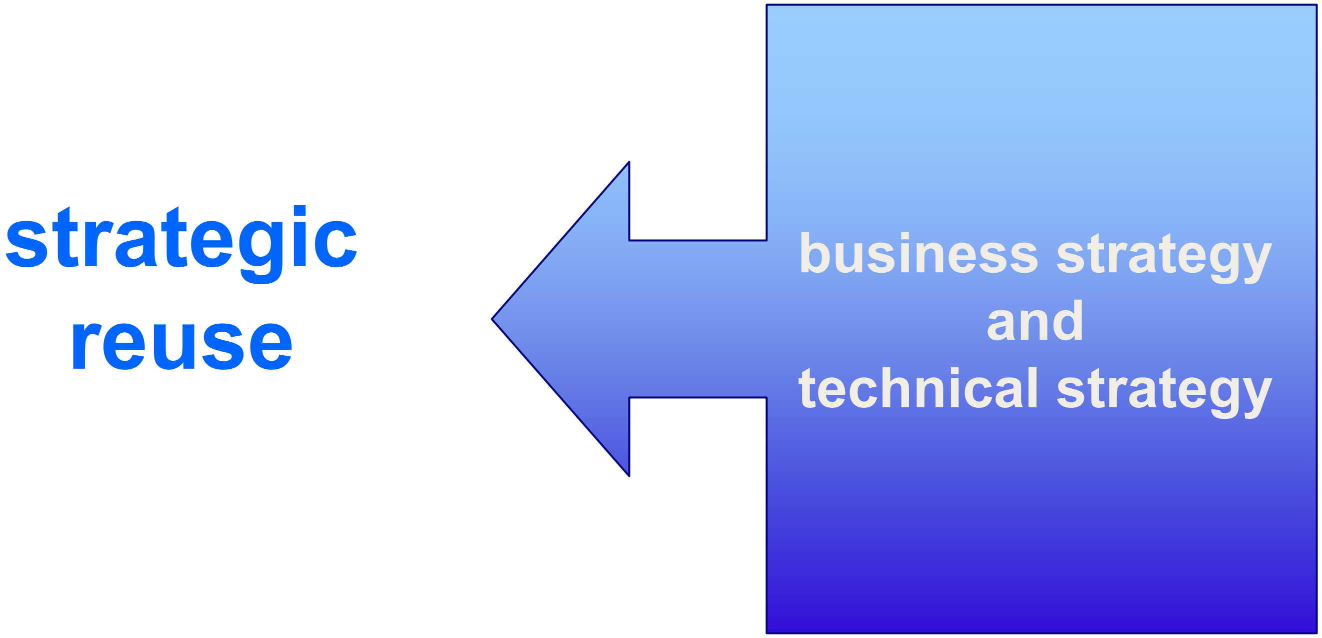
1970's
Modules

1980's
Objects

1990's
Components

Focus was small-grained and opportunistic.
Results fell short of expectations.

Imagine Strategic Reuse



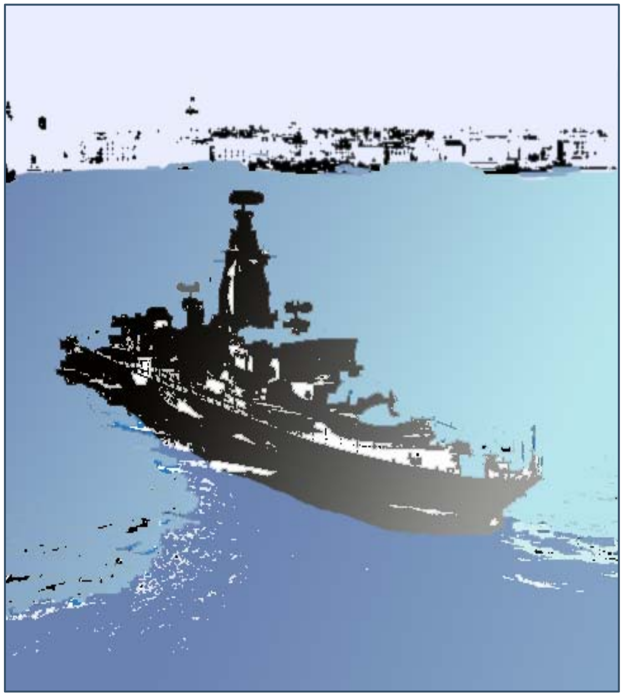
strategic reuse

business strategy
and
technical strategy

CelsiusTech: Ship System 2000

A family of 55 ship systems

- Integration test of 1-1.5 million SLOC requires 1-2 people.
- Rehosting to a new platform/OS takes 3 months.
- Cost and schedule targets are predictably met.
- Performance/distribution behavior are known in advance.
- Customer satisfaction is high.
- Hardware-to-software cost ratio changed from 35:65 to 80:20.



Cummins Inc.: Diesel Engine Control Systems

Over 20 product groups with over 1,000 separate engine applications

- Product cycle time was slashed from 250 person-months to a few person-months.
- Build and integration time was reduced from one year to one week.
- Quality goals are exceeded.
- Customer satisfaction is high.
- Product schedules are met.

National Reconnaissance Office/ Raytheon: Control Channel Toolkit

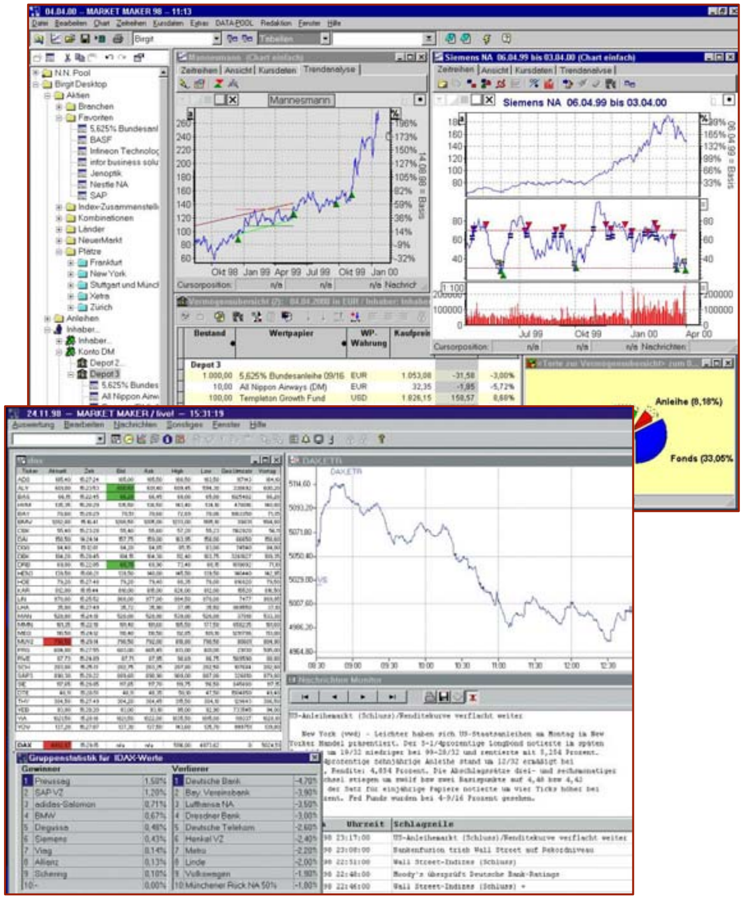
Ground-based spacecraft command and control systems

- increased quality by 10X
- incremental build time reduced from months to weeks
- software productivity increased by 7X
- development time and costs decreased by 50%
- decreased product risk

Market Maker GmbH: MERGER

Internet-based stock market software

- Each product is “uniquely” configured.
- Putting up a customized system takes three days.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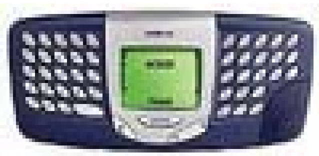
Mannesmann
Siemens NA 06.04.99 bis 03.04.00
24.11.98 – MARKET MAKER / live! – 15:31:19
DAXETR
Gruppenstatistik für IDAX-Werte
Gewinner
Verlierer
Anleihe (8,18%)
Fonds (33,05%)

Nokia Mobile Phones

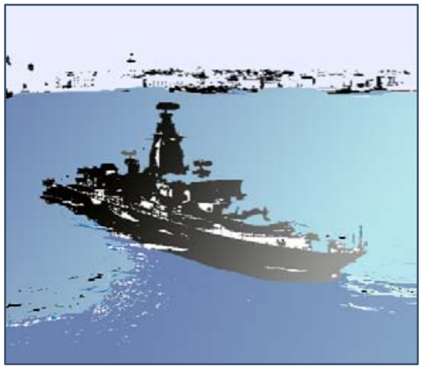
Product lines with 25-30 new products per year



Across products there are

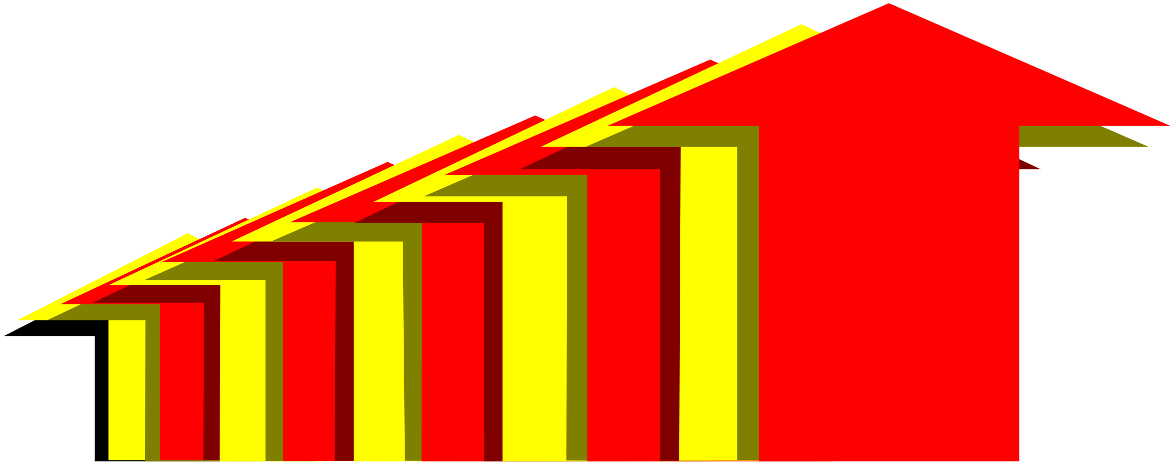
- varying number of keys
- varying display sizes
- varying sets of features
- 58 languages supported
- 130 countries served
- multiple protocols
- needs for backwards compatibility
- configurable features
- needs for product behavior change after release

How Did They Do It?



Software Product Lines

Reuse History: From Ad Hoc to Systematic



1960s
Subroutines

1970s
Modules

1980s
Objects

1990s
Components

2000s
Software
Product Lines

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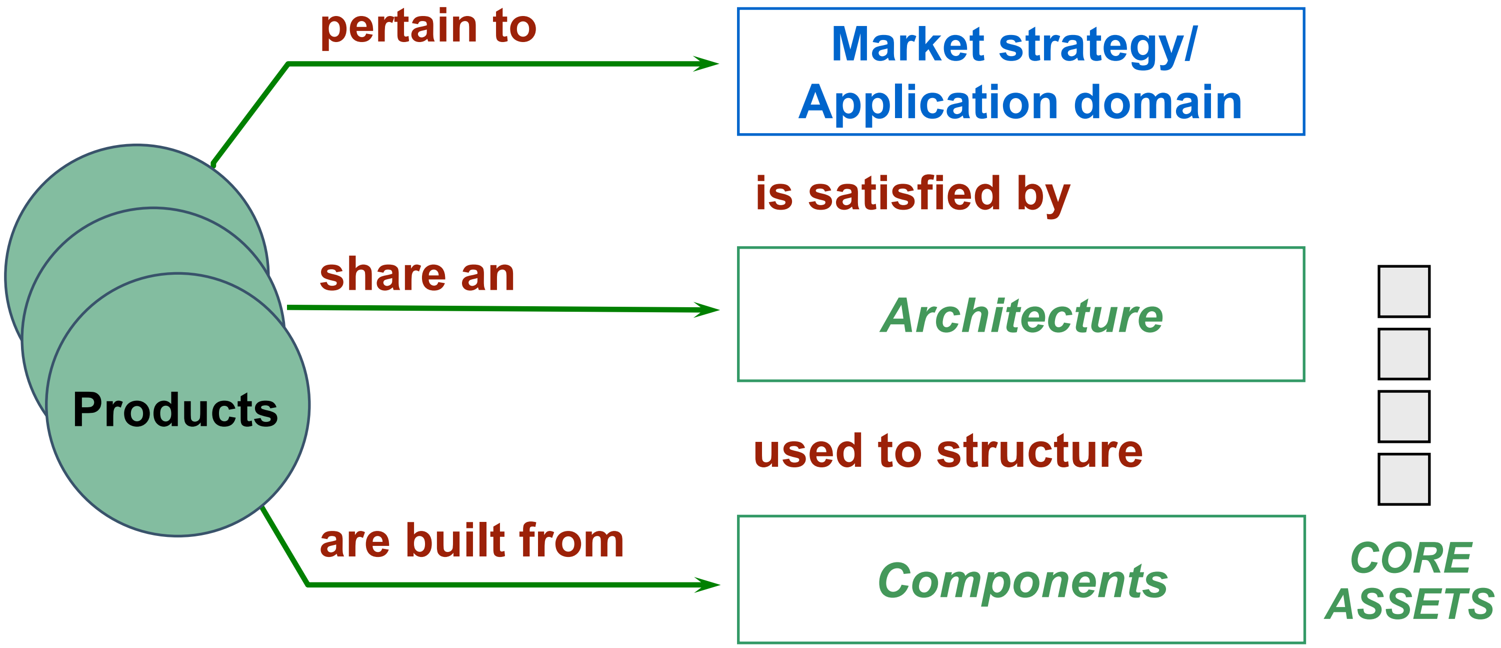
What Is a Software Product Line?

A software product line is a set of software-intensive systems sharing a common, managed set of features that satisfy the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way.

Software Product Lines



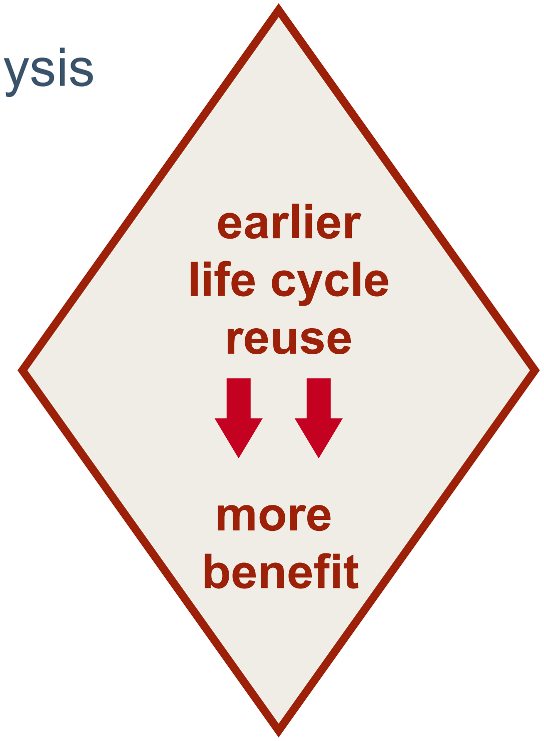
Product lines

- take economic advantage of commonality
- bound variability

How Do Product Lines Help?

Product lines amortize the investment in these and other *core assets*:

- requirements and requirements analysis
- domain model
- software architecture and design
- performance engineering
- documentation
- test plans, test cases, and test data
- people: their knowledge and skills
- processes, methods, and tools
- budgets, schedules, and work plans
- components



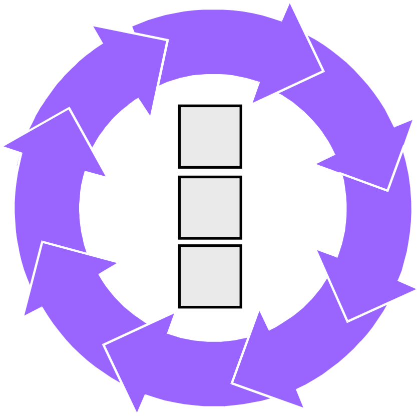
earlier life cycle reuse

more benefit

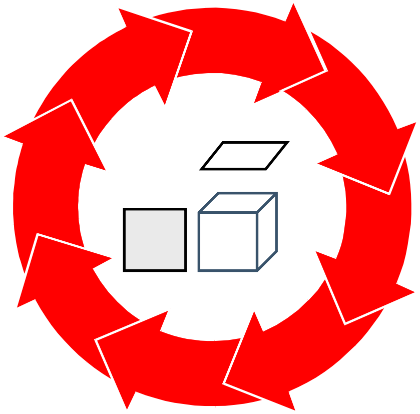
product lines = strategic reuse

The Key Concepts

Use of a core
asset base



in production



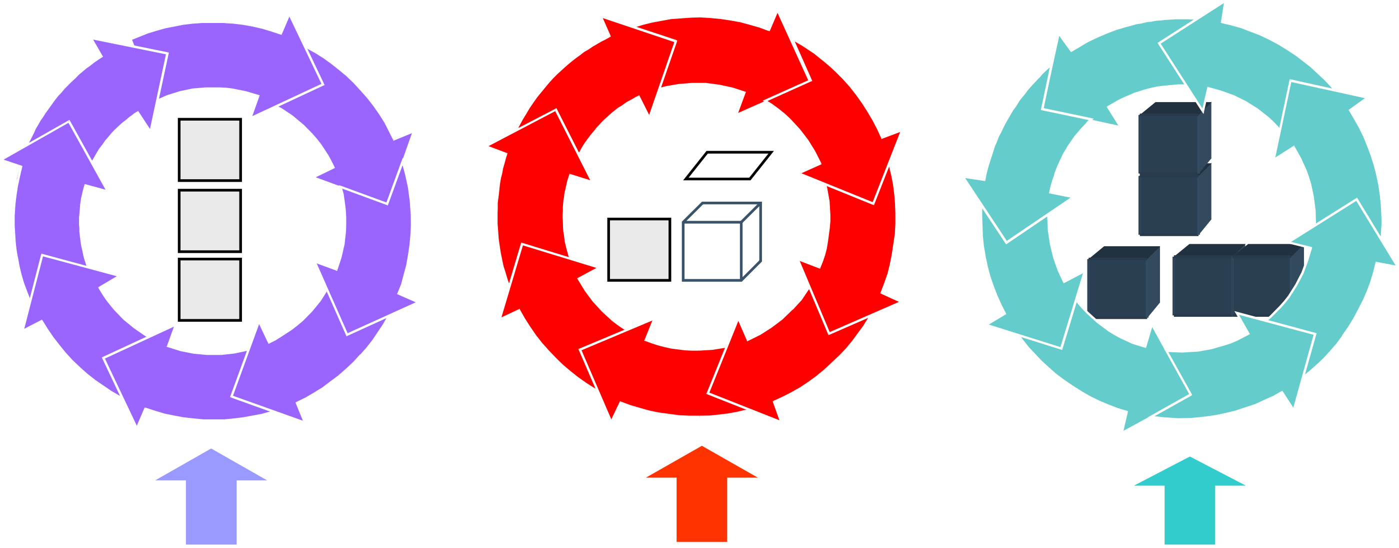
of a related
set of products

The Key Concepts

Use of a core asset base

in production

of a related set of products



Architecture

Production Plan

Scope Definition
Business Case

Software Product Lines Are Not - 1

Fortuitous Small-Grained Reuse

- Reuse libraries containing algorithms, modules, objects, or components
- Benefits depend on
  - software engineer’s predisposition to use what is in the library
  - suitability of library contents for particular needs
  - successful adaptation and integration of library units into the rest of the system
- Reuse is not planned, enabled, or enforced nor are results predictable

Software Product Lines Are Not - 2

Single-System Development with Reuse

- Borrowing opportunistically from previous efforts
- Modifying as necessary for the single system only
- Asset base never cultivated

Just Component-Based Development

- Selection of components from an in-house library or the marketplace
- Missing a product line architecture and a production plan as well as management infrastructure

Software Product Lines Are Not - 3

Just a Configurable Architecture

- Involves use of a reference architecture or application framework
- Does not involve the planned reuse of other assets

Versions of Single Products

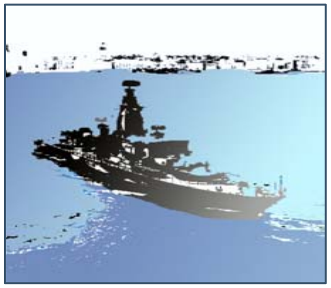
- Involves sequential release of products over time.
- No simultaneous release/support of multiple products

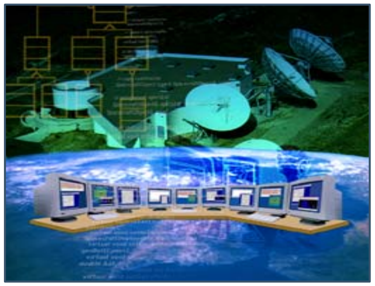
Just a Set of Technical Standards

- Constraints to promote interoperability and to decrease the cost associated with maintenance and support of commercial components
- Does not provide assets and production capability

Product Lines Are

Software product lines involve strategic, planned reuse that yields predictable results.





Commercial Examples

Successful software product lines have been built for families of

- mobile phones
- command and control ship systems
- ground-based spacecraft systems
- avionics systems
- command and control/situation awareness systems
- pagers
- engine control systems
- billing systems
- web-based retail systems
- printers
- consumer electronic products
- acquisition management enterprise systems

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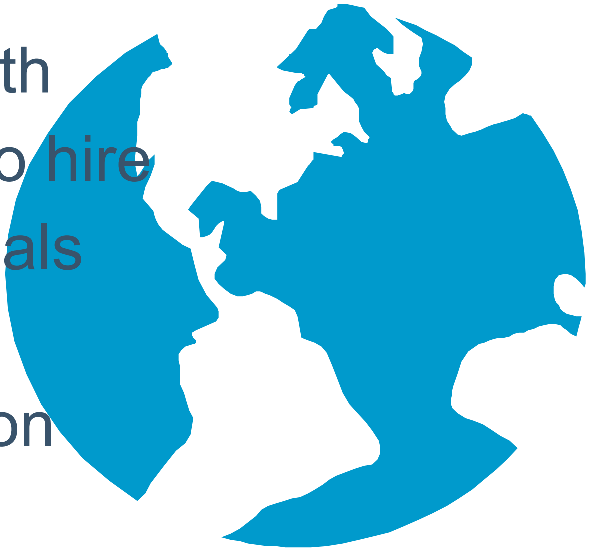
Real World Motivation

Organizations use product line practices to:

- achieve large scale productivity gains
- improve time to market
- maintain market presence
- sustain unprecedented growth
- compensate for an inability to hire
- achieve systematic reuse goals
- improve product quality
- increase customer satisfaction
- enable mass customization
- get control of diverse product configurations



Summary: Organizational Benefits

Improved productivity
by as much as 10x

Decreased time to market (to field, to launch...)
by as much as 10x

Decreased cost
by as much as 60%

Decreased labor needs
by as much as 10X fewer software developers

Increased quality
by as much as 10X fewer defects

Product line practice permits predictable “faster, better, cheaper.”

Individuals Who Benefit

CEO

Architect

COO

Core Asset Developer

Technical Manager

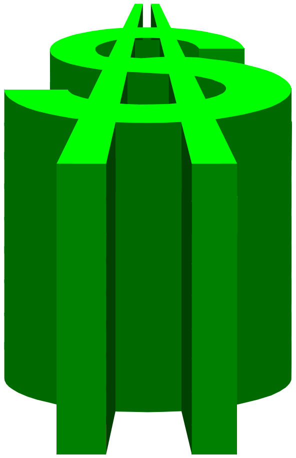
Marketer

End User

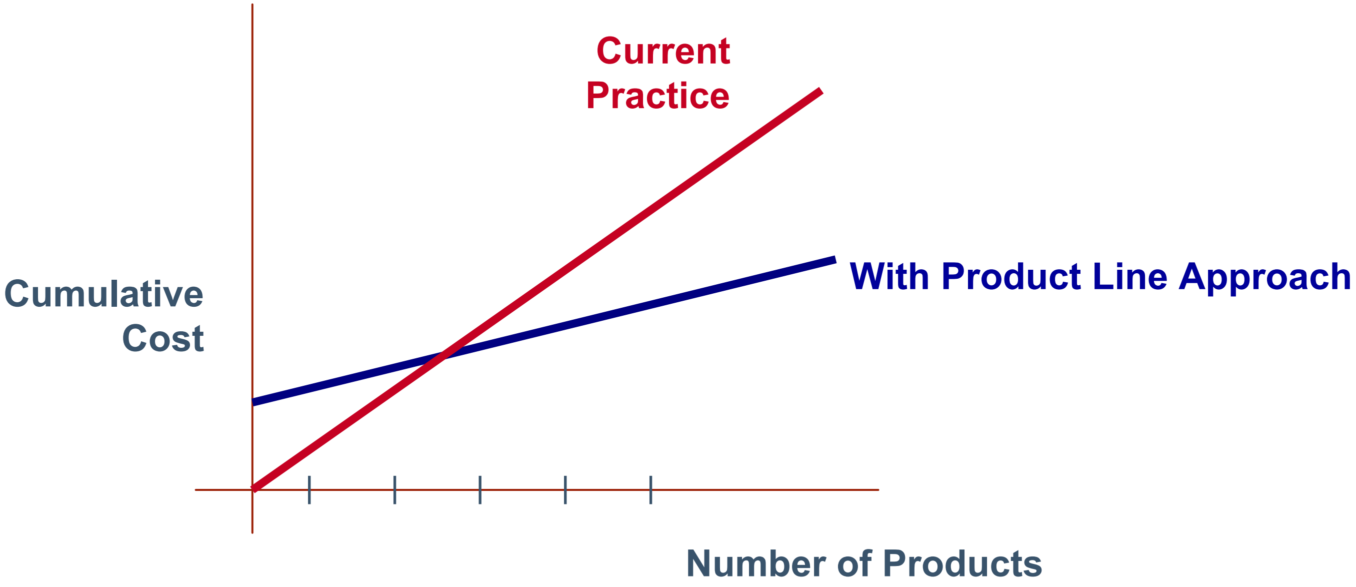
Customer

Costs of a Software Product Line

Core Assets	Costs
architecture	must support variation inherent in the product line
software components	must be designed to be general without a loss of performance; must build in support for variation points
test plans, test cases, test data	must consider variation points and multiple instances of the product line
business case and market analysis	must address a family of software products, not just one product
project plans	must be generic or be made extensible to accommodate product variations
tools and processes	must be more robust
people, skills, training	must involve training and expertise centered around the assets and procedures associated with the product line

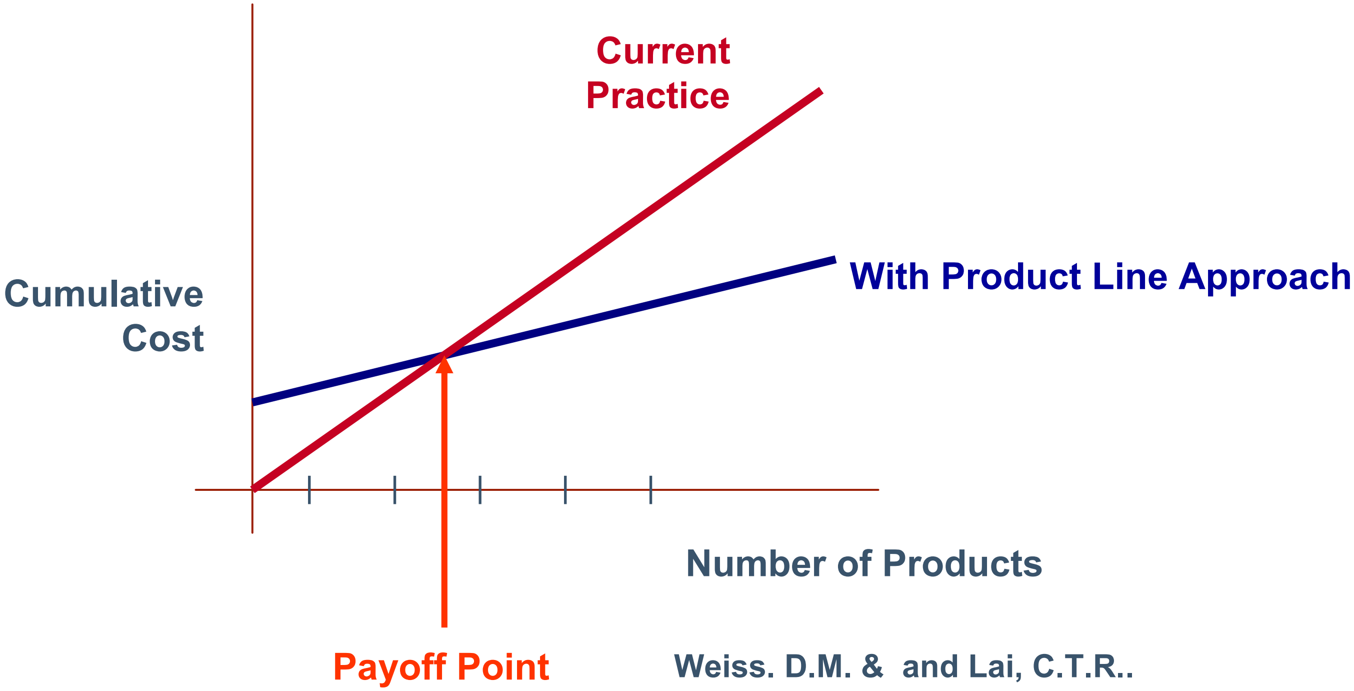


Economics of Product Lines



Weiss. D.M. & and Lai, C.T.R..
Software Product-Line Engineering:
A Family-Based Software Development Process
Reading, MA: Addison-Wesley, 1999.

Economics of Product Lines



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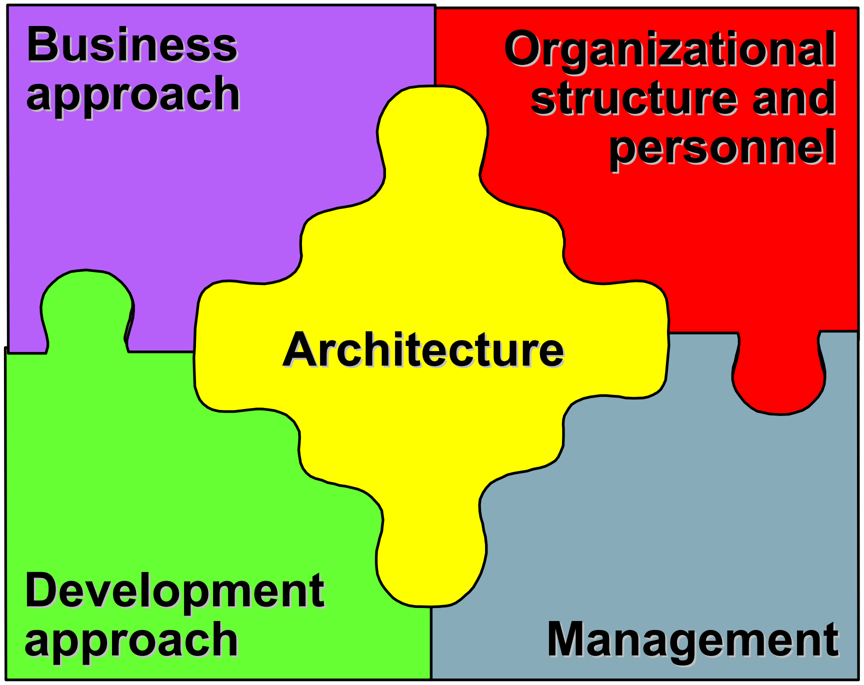
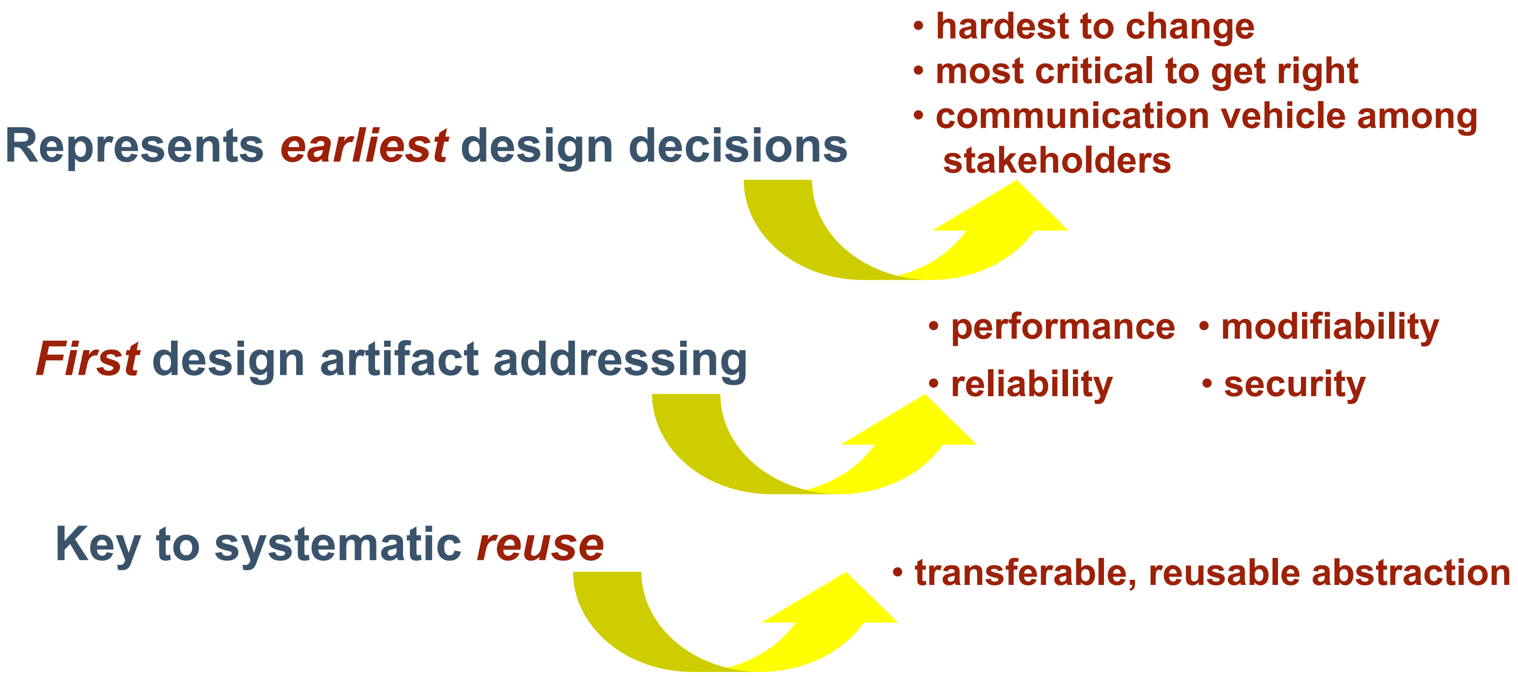
Necessary Changes



The product line architecture is the foundation of everything.

Why is Software Architecture Important?



Represents *earliest* design decisions

- hardest to change
- most critical to get right
- communication vehicle among stakeholders

First design artifact addressing

- performance
- modifiability
- reliability
- security

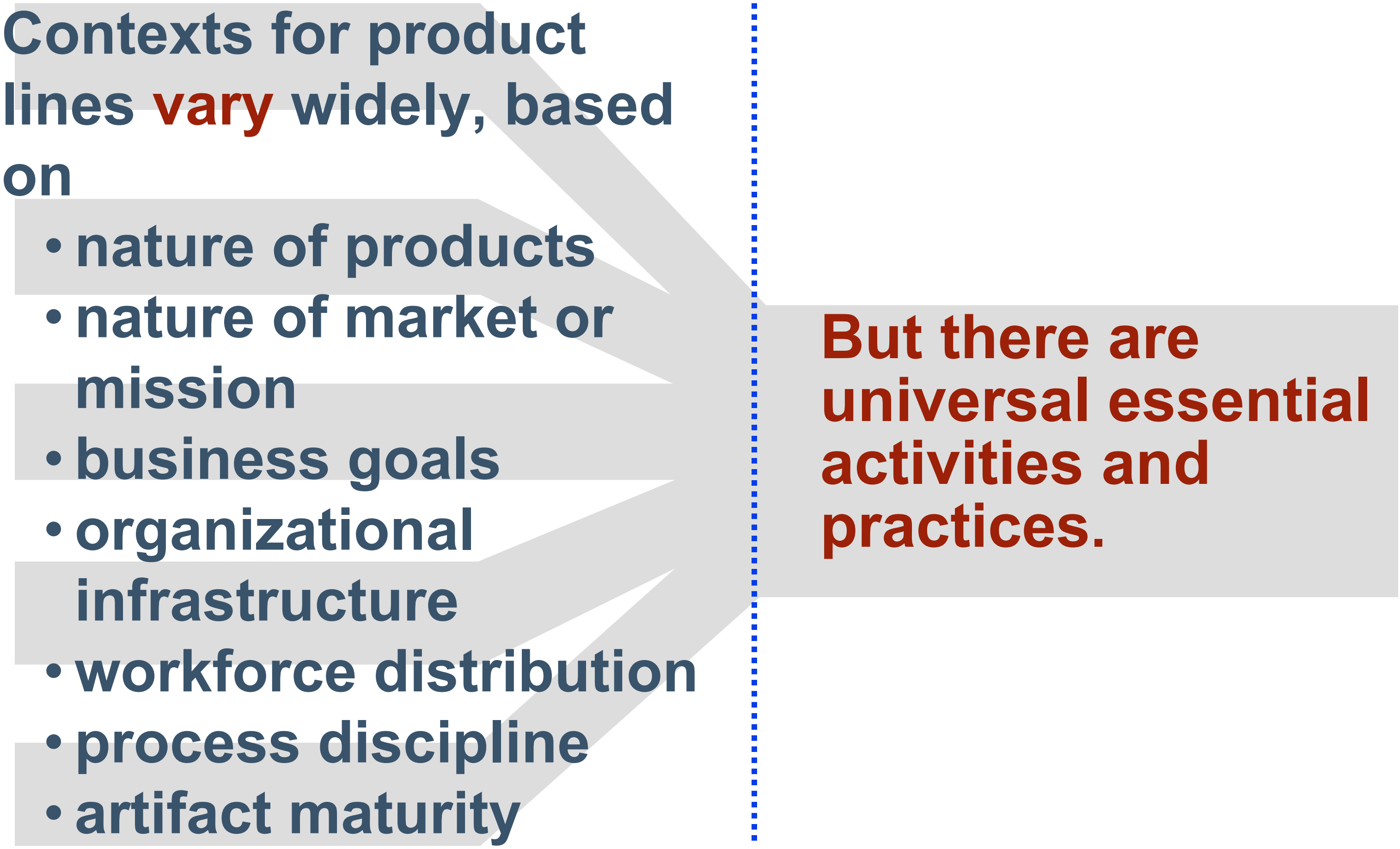
Key to systematic *reuse*

- transferable, reusable abstraction

The right architecture paves the way for system success.

The wrong architecture usually spells some form of disaster.

Product Line Practice



Contexts for product lines vary widely, based on

- nature of products
- nature of market or mission
- business goals
- organizational infrastructure
- workforce distribution
- process discipline
- artifact maturity

But there are universal essential activities and practices.

A Framework for Software Product Line Practice^{SM}

A description of the essential activities and practice areas form a conceptual framework for software product line practice.

This Framework is evolving based on the experience and information provided by the community.

Version 4.0 – in *Software Product Lines: Practices and Patterns*

Version 4.2 – http://www.sei.cmu.edu/plp/framework.html

SEI Information Sources

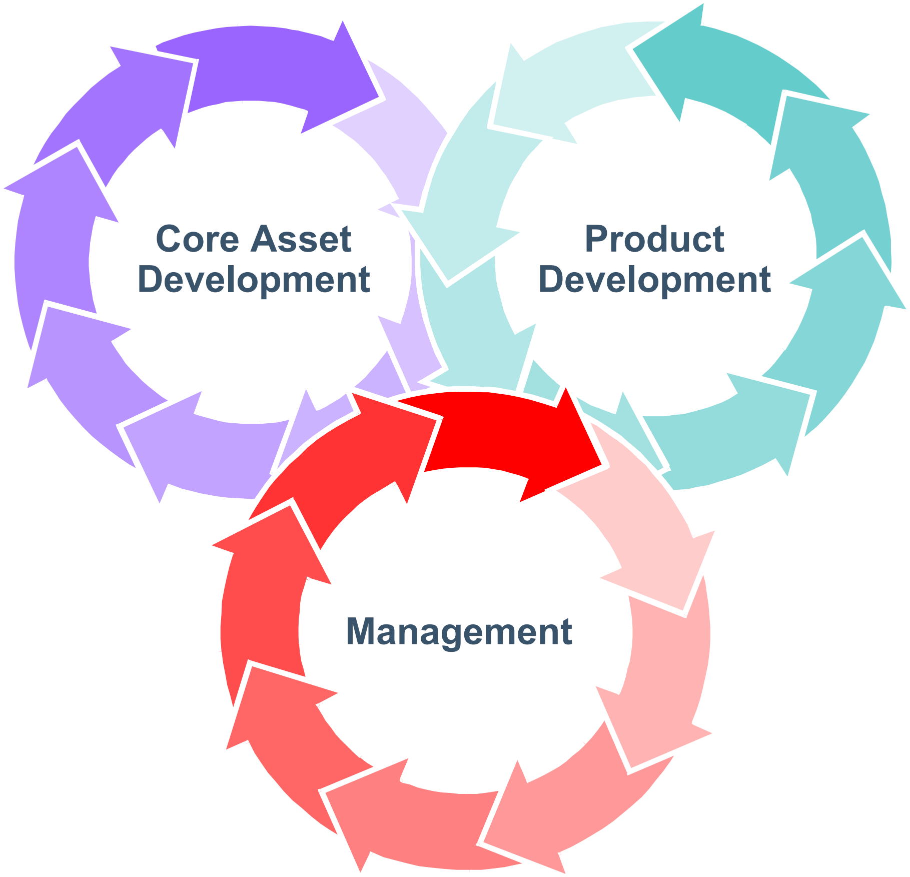
Case studies,
experience reports,
and surveys

Workshops
and
conferences

Applied research

Collaborations
with customers
on actual product lines

The Three Essential Activities



Core Asset Development

Product Development

Management

The Nature of the Essential Activities

All three activities are interrelated and highly iterative.

There is no “first” activity.

- In some contexts, existing products are mined for core assets.
- In others, core assets may be developed or procured for future use.

There is a strong feedback loop between the core assets and the products.

Strong management at multiple levels is needed throughout.

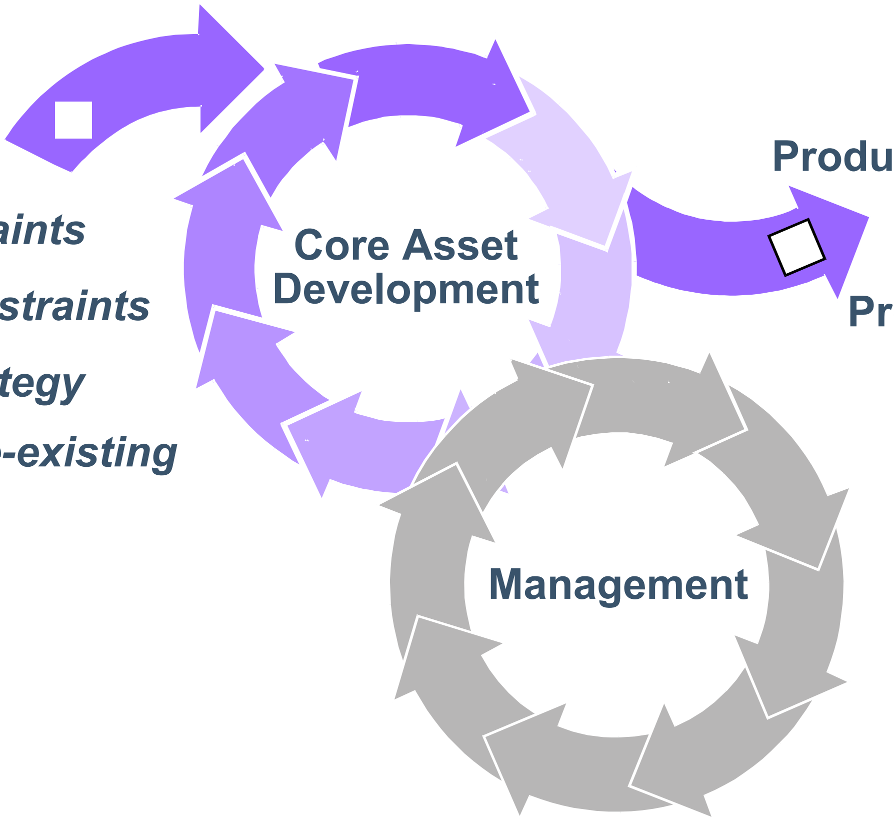
Core Asset Development

Product Constraints

Production Constraints

Production Strategy

Inventory of Pre-existing Assets

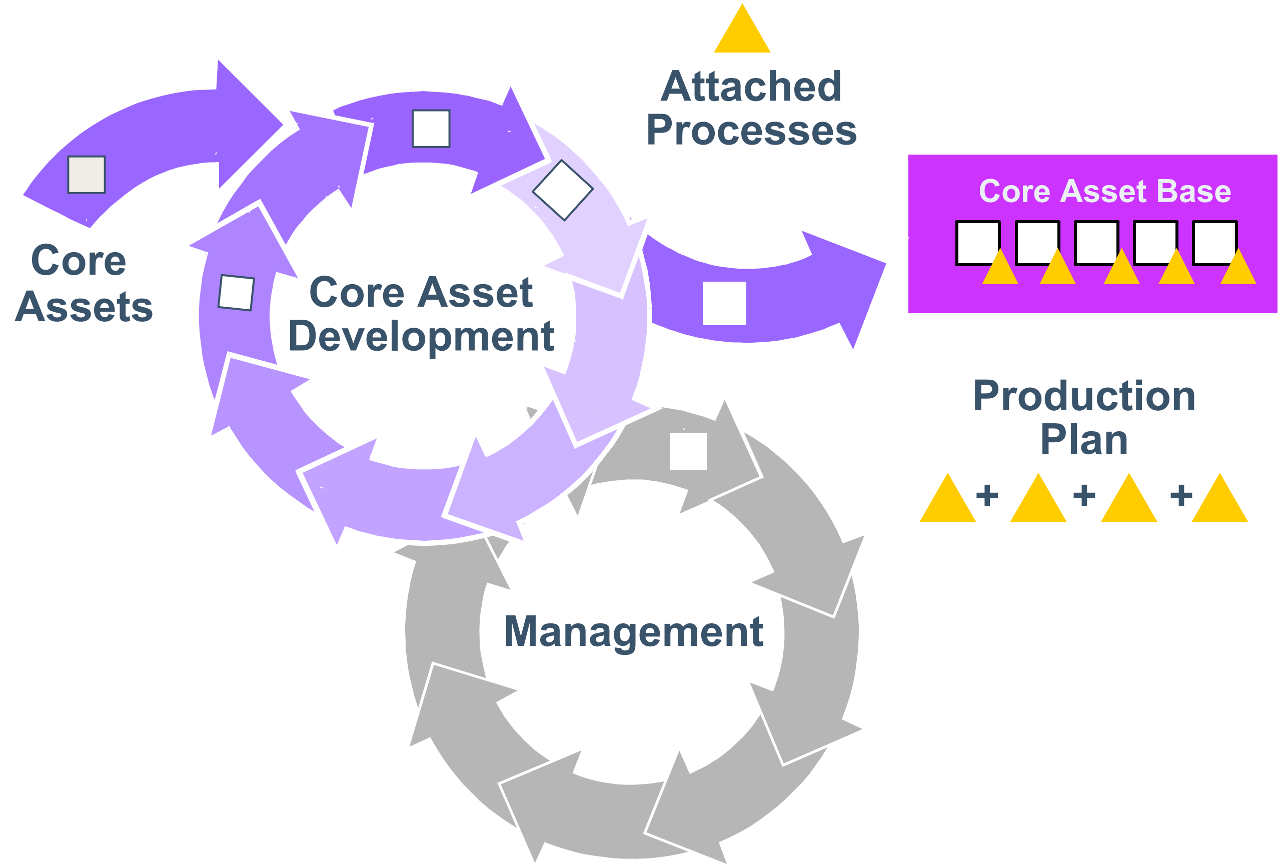


Product Line Scope

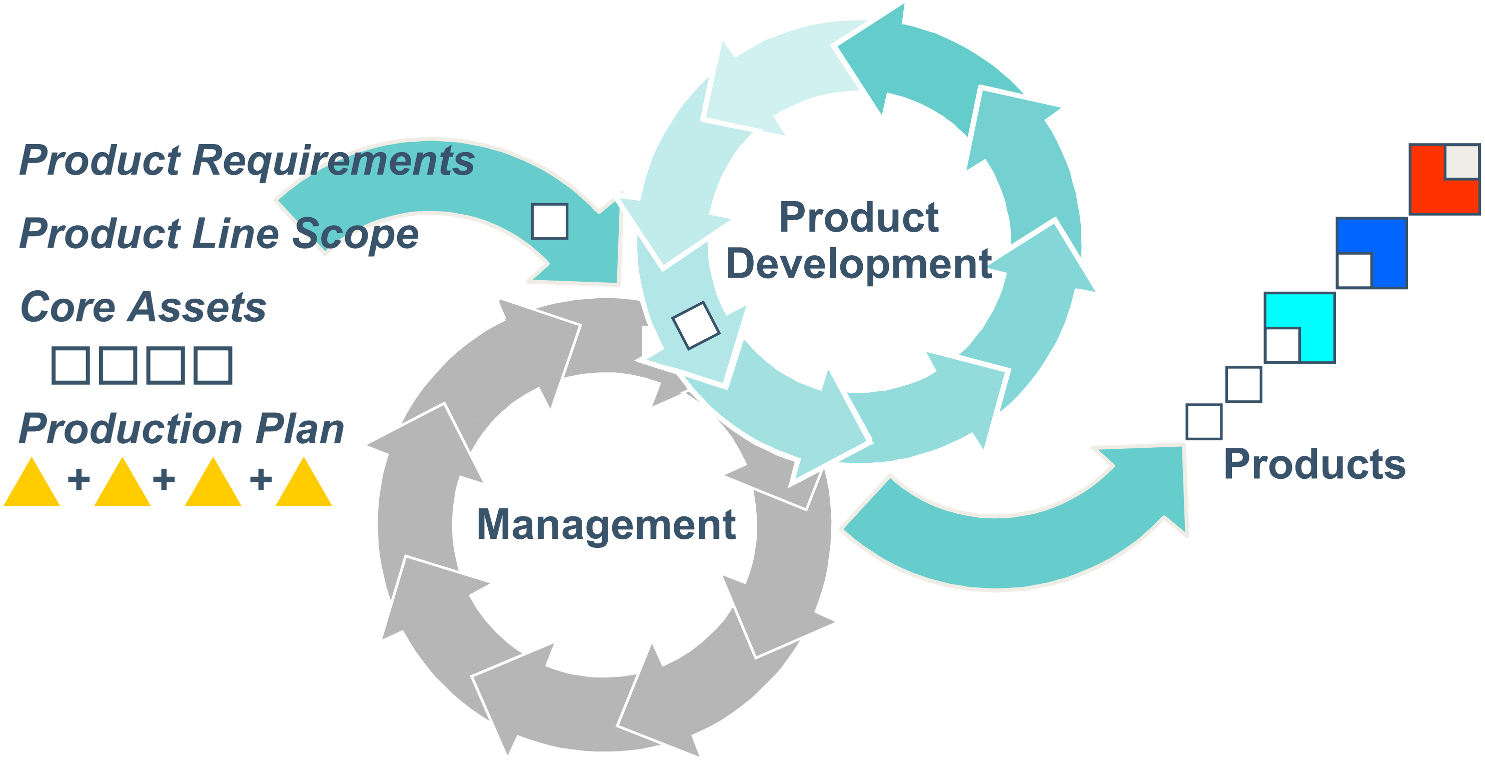
Core Assets

Production Plan

Attached Processes



Product Development



Product Requirements

Product Line Scope

Core Assets

□□□□

Production Plan

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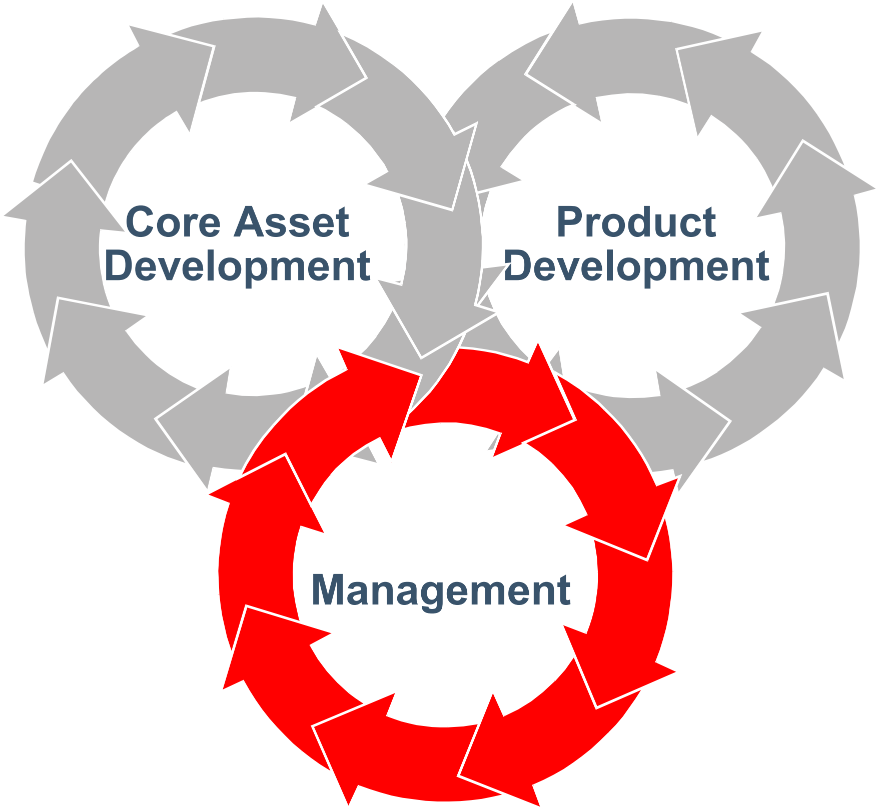
Product Development

Management

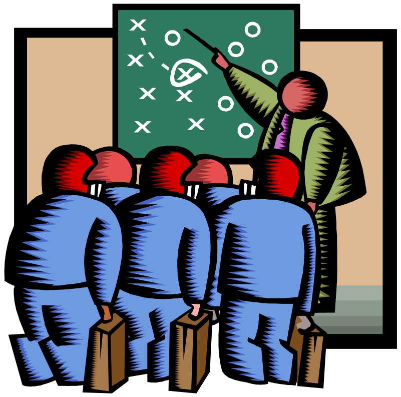
Products

Management



Management

Management at multiple levels plays a critical role in the successful product line practice by



- achieving the right organizational structure
- allocating resources
- coordinating and supervising
- providing training
- rewarding employees appropriately
- developing and communicating an acquisition strategy
- managing external interfaces
- creating and implementing a product line adoption plan
- launching and institutionalizing the approach in a manner appropriate to the organization

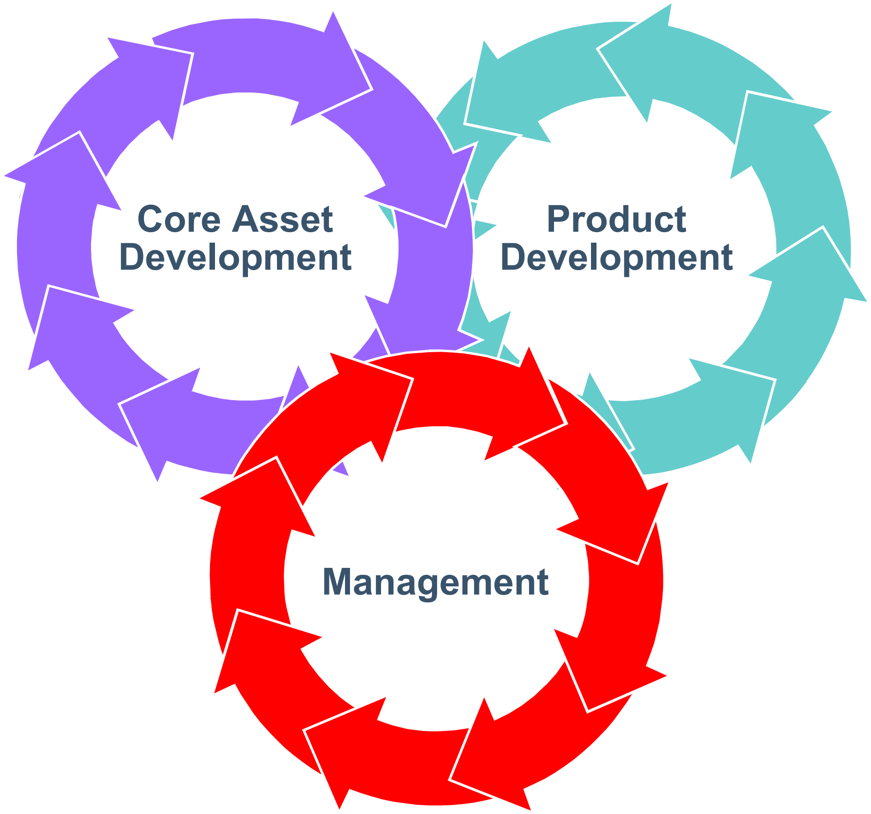
Managing a Software Product Line Requires Leadership

A key role for a software product line manager is that of champion.

The champion must

- set and maintain the vision
- ensure that the appropriate goals and measures are in place
- “sell” the product line up and down the chain
- sustain morale
- deflect potential derailments
- solicit feedback and continuously improve the approach

Essential Product Line Activities



Each of these is essential, as is the blending of all three.

Different Approaches - 1

Proactive: Develop the core assets first.

- Develop the scope first and use it as a “mission” statement.
- Products come to market quickly with minimum code writing.
- requires upfront investment and predictive knowledge

Reactive: Start with one or more products.

- From them, generate the product line core assets and then future products; the scope evolves more dramatically.
- much lower cost of entry
- The architecture and other core assets must be robust, extensible, and appropriate to future product line needs.

Different Approaches - 2

Incremental: In either a reactive or proactive approach, it is possible to develop the core asset base in stages, while planning from the beginning to develop a product line.

- Develop part of the core asset base, including the architecture and some of the components.
- Develop one or more products.
- Develop part of the rest of the core asset base.
- Develop more products.
- Evolve more of the core asset base.
- …

Alternate Terminology

Our Terminology	Alternate Terminology
Product Line	Product Family
Core Assets	Platform
Business Unit	Product Line
Product	Customization
Core Asset Development	Domain Engineering
Product Development	Application Engineering

Driving the Essential Activities

Beneath the level of the essential activities are essential practices that fall into practice areas.

A practice area is a body of work or a collection of activities that an organization must master to successfully carry out the essential work of a product line.

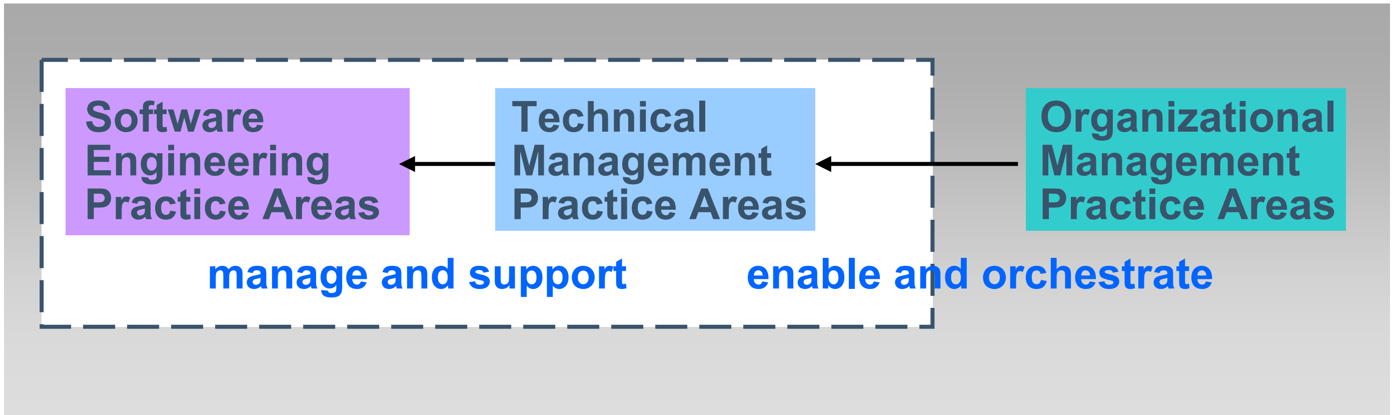
Practice Areas Categories

Software Engineering

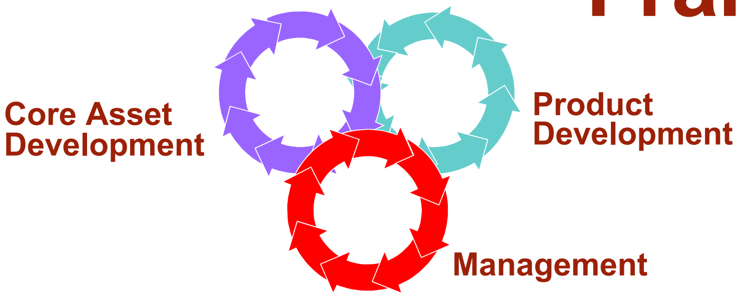
Technical Management

Organizational Management

Relationships among Categories of Practice Areas


Software Engineering Practice Areas
Technical Management Practice Areas
Organizational Management Practice Areas
manage and support
enable and orchestrate

Framework



Essential Activities

- Architecture Definition
- Architecture Evaluation
- Component Development
- COTS Utilization
- Mining Existing Assets
- Requirements Engineering
- Software System Integration
- Testing
- Understanding Relevant Domains

Software Engineering

- Configuration Management
- Data Collection, Metrics, and Tracking
- Make/Buy/Mine/Commission Analysis
- Process Definition
- Scoping
- Technical Planning
- Technical Risk Management
- Tool Support

Technical Management

- Building a Business Case
- Customer Interface Management
- Implementing an Acquisition Strategy
- Funding
- Launching and Institutionalizing
- Market Analysis
- Operations
- Organizational Planning
- Organizational Risk Management
- Structuring the Organization
- Technology Forecasting
- Training

Organizational Management

Practice Areas

Architecture Definition

The software architecture of a software system is the structure or structures of the system, which comprise software elements, the externally visible properties of those elements, and the relationships among them.[1]

Architecture is

- the blueprint for a project
- the carrier of most system quality attributes
- a forum for resource tradeoffs
- a contract that allows multi-party development
- an essential part of complex systems

Bass, L.; Clements, P. & Kazman, R. *Software Architecture in Practice, 2nd Edition.* Reading, MA: Addison-Wesley, 2003.

Architecture Definition: Aspects Peculiar to Product Lines

A product line architecture must

- apply to all members of the product line (even if their functions and qualities differ)
- embody the commonalities and variabilities of the family members
- include specific mechanisms for variation

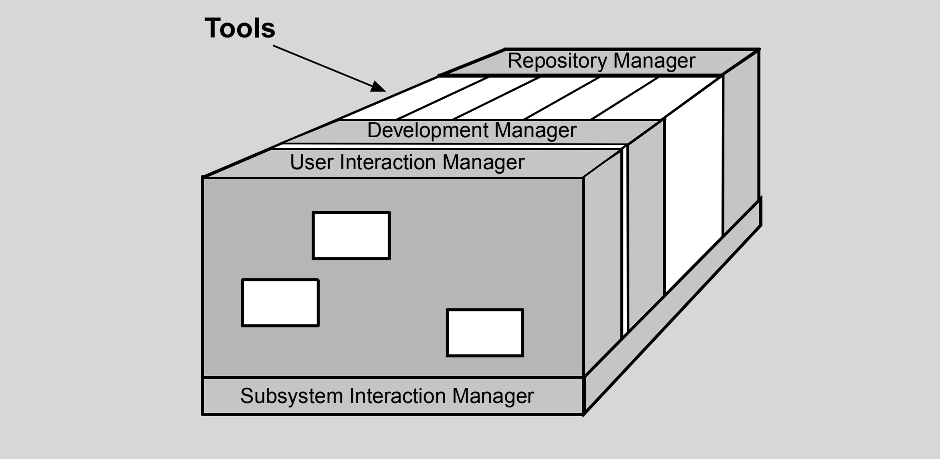
Architecture Definition: Specific Practices

Architecture variability mechanisms

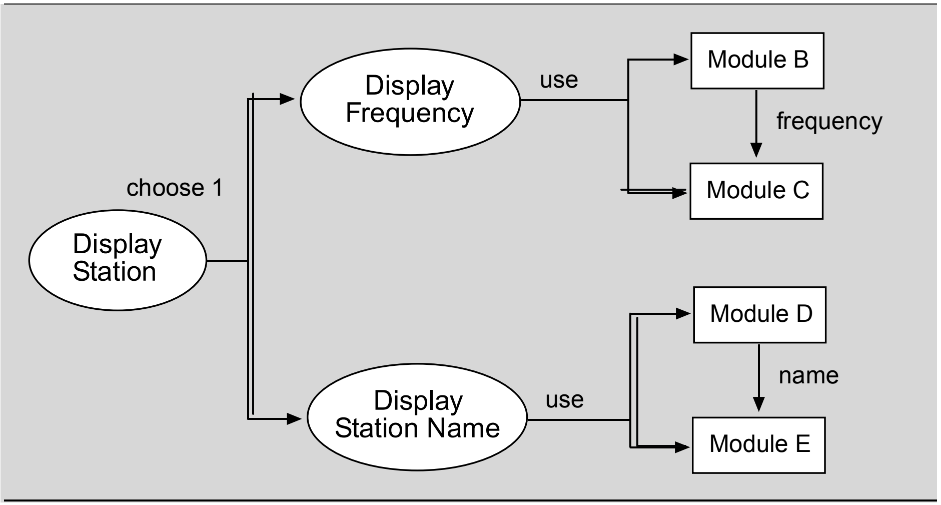
- component replacement, omission, replication
- parameterization (including macros, templates)
- compile-time selection of different implementations (e.g., *#ifdef*)
- OO techniques: inheritance, specialization, and delegation
- configuration and module interconnection languages
- generation and generators
- aspect-oriented programming
  - an approach for modularizing system properties that otherwise would be distributed across modules
- application frameworks

Examples of Variability

Reference architectures with slots for plug-in components



Variation points within a family of products: Document with a decision tree that shows the choices available



Important Concepts

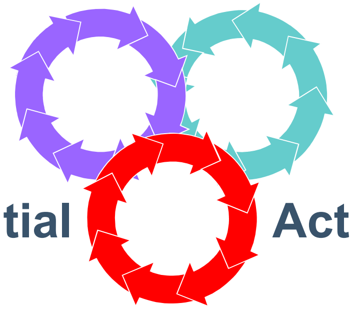
Localization
Variability mechanism
Conditional process
Supporting elements
Dependencies

Dilemma: How Do You Apply the 29 Practice Areas?

Organizations still have to figure out how to put the practice areas into play.

Twenty-nine is a big number.

Help to Make It Happen



Essential Activities

Practice Areas

Software Engineering	Technical Management	Organizational Management

Guidance

Case Studies

Patterns

Probe

Case Studies

CelsiusTech *– CMU/SEI-96-TR-016*
http://www.sei.cmu.edu/publications/documents/01.reports/96.tr.016.html

Cummins, Inc. *Software Product Lines: Practices and Patterns*

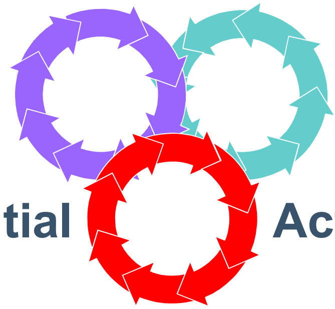
Market Maker *Software Product Lines: Practices and Patterns*

NRO/Raytheon *– CMU/SEI-2001-TR-030*
http://www.sei.cmu.edu/publications/documents/01.reports/02tr030.html

NUWC *– CMU/SEI-2002-TN-018*
http://www.sei.cmu.edu/publications/documents/02.reports/02tn018.html

Salion, Inc. *– CMU/SEI-2002-TR-038*
http://www.sei.cmu.edu/publications/documents/02.reports/02tr038.html

Help to Make It Happen



Essential Activities

Practice Areas

Software Engineering	Technical Management	Organizational Management

Guidance

Case Studies *Patterns* *Probe*

Patterns Can Help

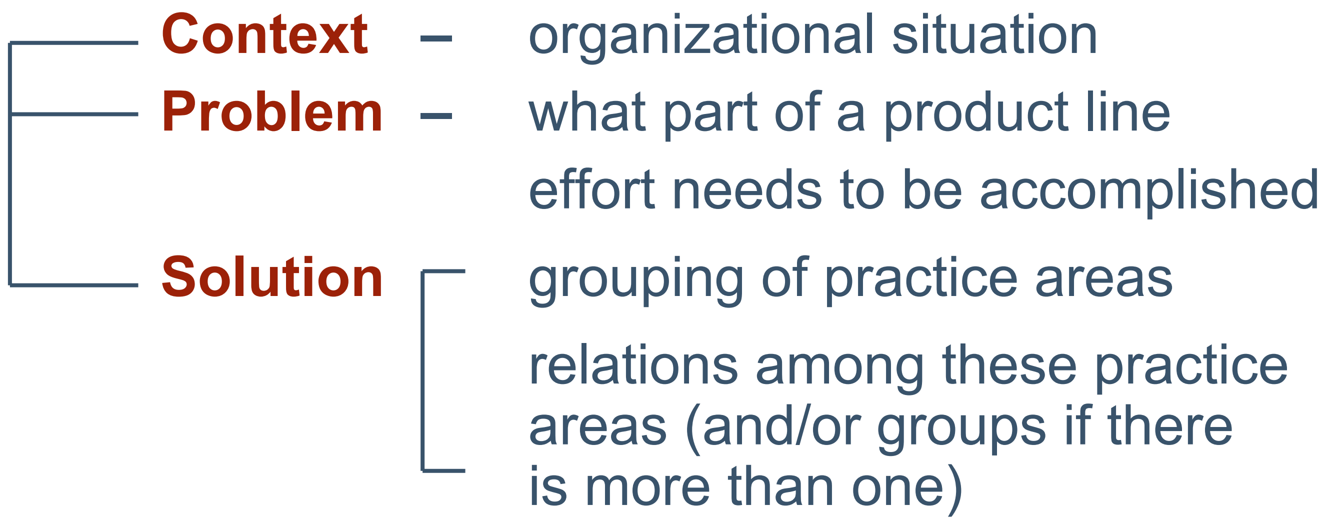
Patterns are a way of expressing common context and problem-solution pairs.

Patterns have been found to be useful in building architecture, economics, software architecture, software design, software implementation, process improvement, and others.

Patterns assist in effecting a divide and conquer approach.

Software Product Line Practice Pattern

Pattern



Context – organizational situation

Problem – what part of a product line effort needs to be accomplished

Solution

- grouping of practice areas
- relations among these practice areas (and/or groups if there is more than one)

What to Build Pattern - 1

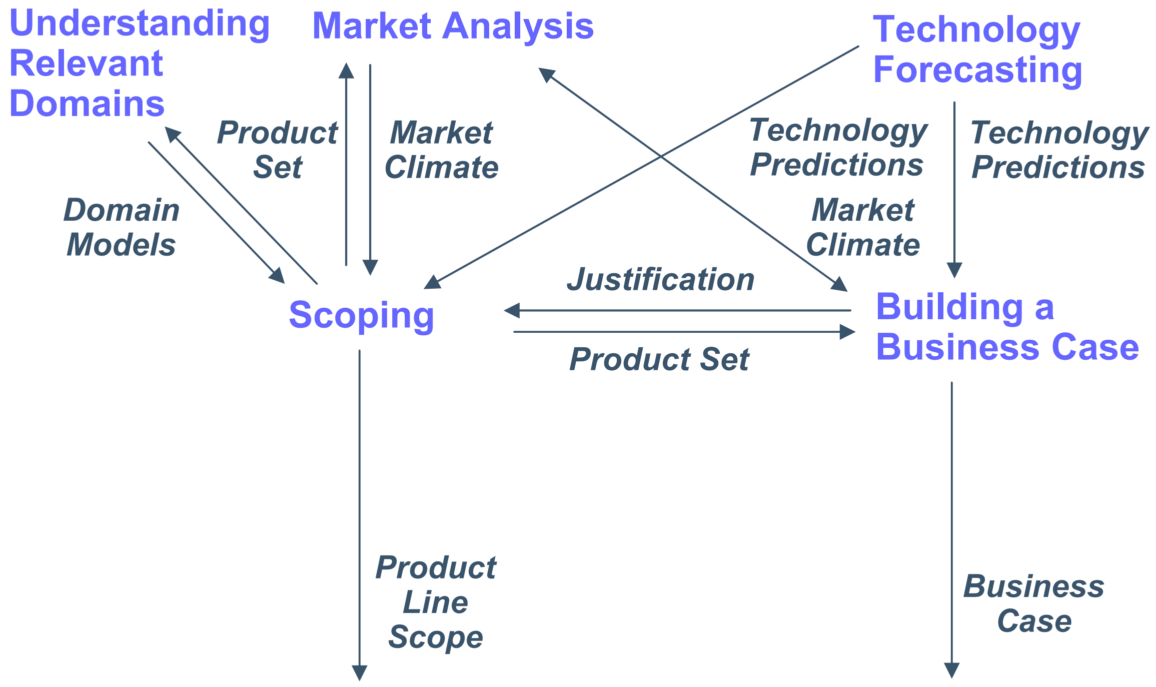
Name:

The *What to Build* pattern helps an organization determine what products ought to be in its software product line – what products to build.

Context:

An organization has decided to field a software product line and knows the general product area for the set of products.

What to Build Pattern - 2



Dynamic Structure

Factory Pattern - 1

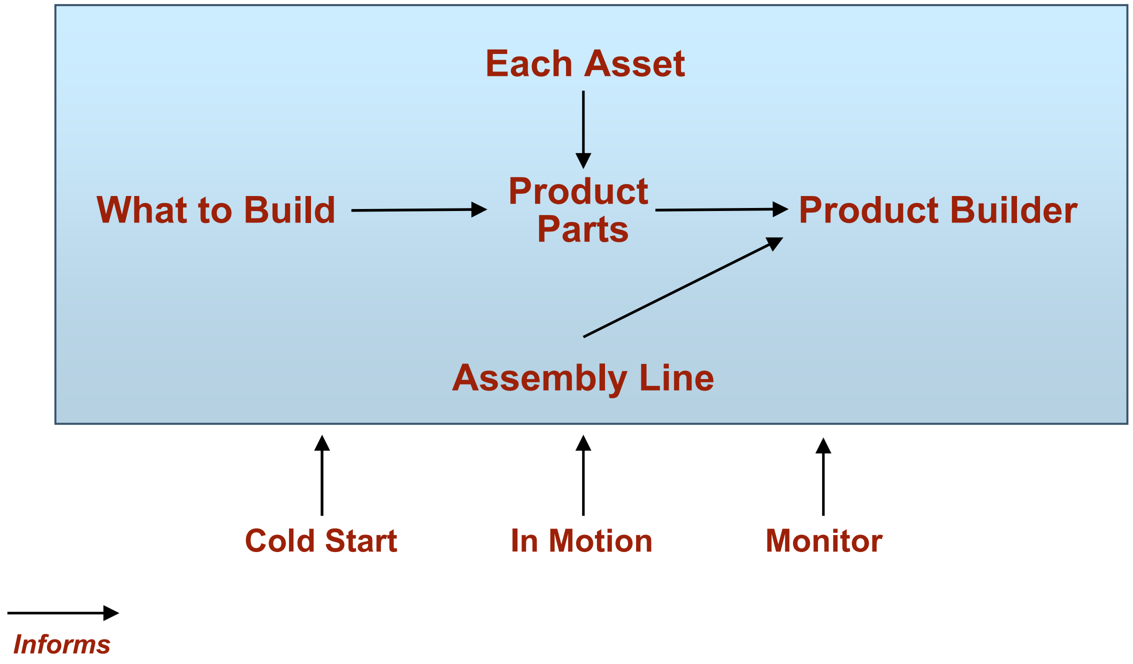
Name:

The ***Factory*** patterns is a composite pattern that describes the entire product line organization.

Context:

An organization is considering (or fielding) a product line.

Factory Pattern - 2

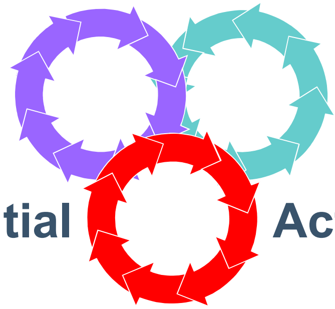


Dynamic Structure

Current Set of Patterns

Pattern	Variants
Assembly Line	
Cold Start	Warm Start
Curriculum	
Each Asset	Each Asset Apprentice Evolve Each Asset
Essentials Coverage	
Factory	Adoption Factory
In Motion	
Monitor	
Process	Process Improvement
Product Builder	Product Gen
Product Parts	Green Field Barren Field Plowed Field
What to Build	Analysis Forced March

Help to Make It Happen



Essential Activities

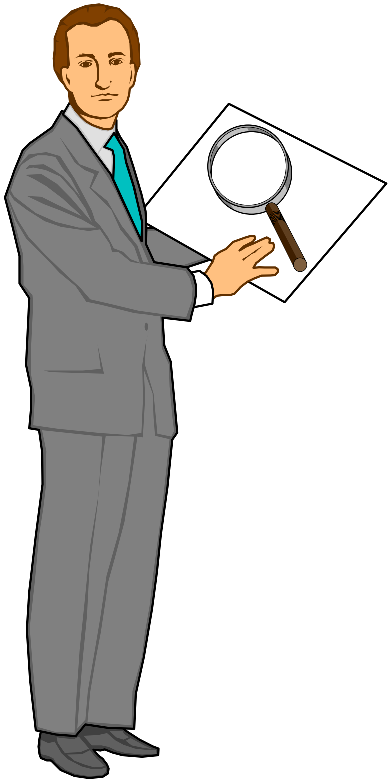
Practice Areas

Software Engineering	Technical Management	Organizational Management

Guidance

Case Studies *Patterns* *Probe*

What Is a Product Line Technical Probe?



A method for examining an organization’s readiness to adopt or ability to succeed with a software product line approach

- diagnostic tool based on the SEI Framework for Software Product Line Practice
- Practice areas are the basis of data collection and analysis.

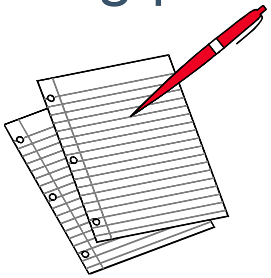
PLTP Outcomes

Set of findings that portray organizational

- strengths
- challenges

with regard to a product line approach

Findings can be used to develop an action plan with the goal of making the organization more capable of achieving product line success.



PLTP Applicability

When an organization

- is considering adopting a software product line approach
- has already initiated a software product line approach

Getting There

Product line adoption involves moving from some form of developing software-intensive systems with a single-system mentality to developing them as a software product line.

The Adoption Endgame

Effectively achieve an operational product line.

- have
  - a core asset base
  - supportive processes and organizational structures
- develop products from that asset base in a way that achieves business goals
- improve and extend the software product line adoption effort as long as it makes sense

Barriers to Product Line Adoption

Cost, cost, and cost

Barriers to Product Line Adoption

Time, time,
and time

Time Needed for Product Line Adoption

Time is needed to

- launch the product line effort
  - educate
  - address cultural barriers
- define supportive processes and organizational structures
- develop a core asset base
- lead the organization to an operational product line
- continue to do business

An organization can’t go out of business while adopting a product line approach.

More Barriers

Lack of knowledge
Need for organizational change
Cultural resistance
Lack of sufficient management support
Lack of necessary talent
Incompatible development processes
Globalization of workforce
Stove-piped mentality
No clear path to follow
Others?????

Factors Influencing Adoption

Organizational Context

product line readiness 🟦

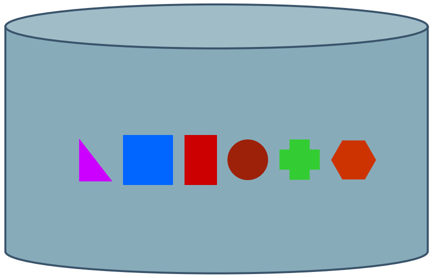
barriers 🟥

enablers ◣

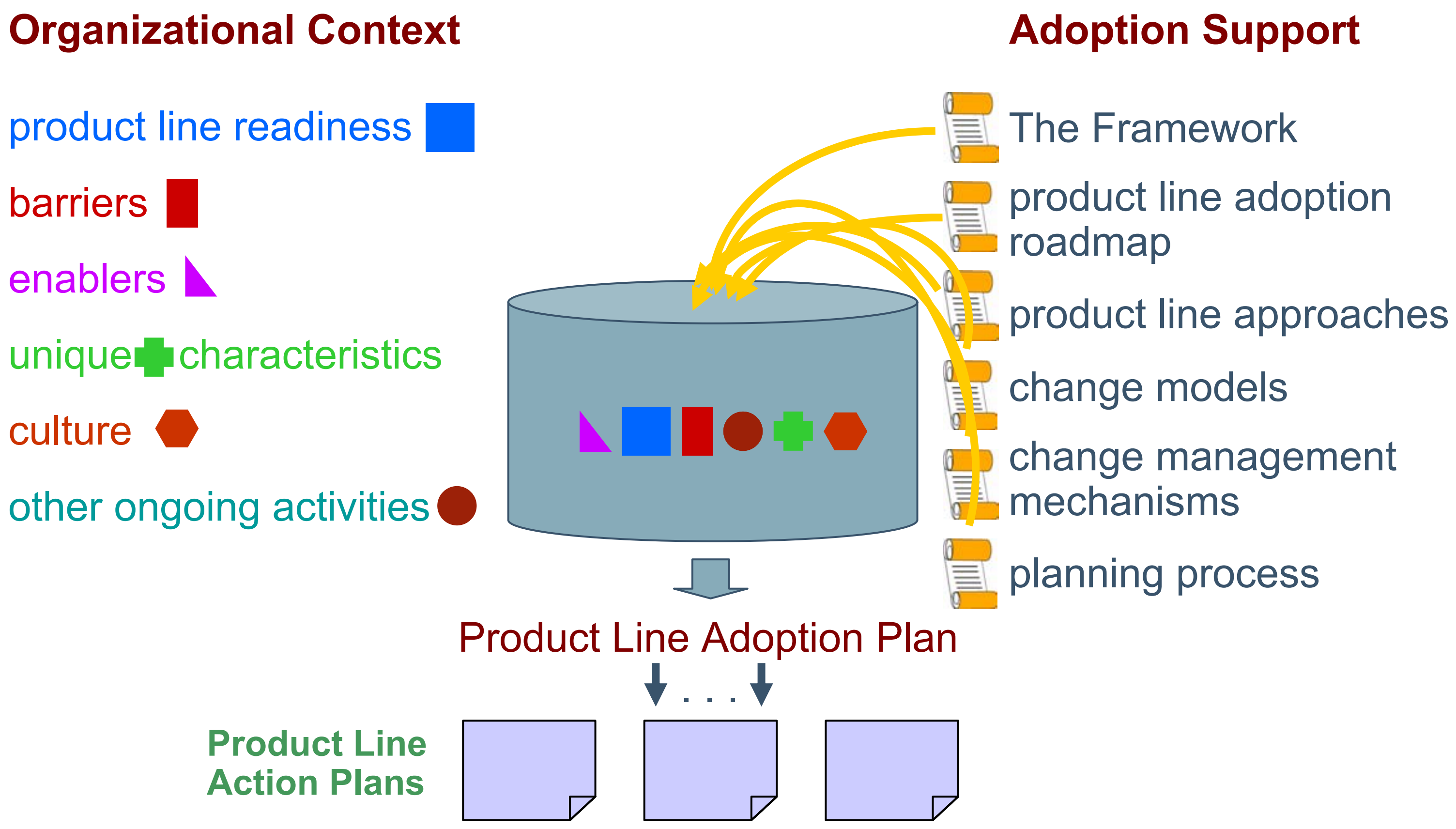
unique✚characteristics

culture ⬣

other ongoing activities ●



Factors Influencing Adoption



Organizational Context

- product line readiness 🟦
- barriers 🟥
- enablers ◣
- unique ✚ characteristics
- culture ⬢
- other ongoing activities ●

Adoption Support

- The Framework
- product line adoption roadmap
- product line approaches
- change models
- change management mechanisms
- planning process

Product Line Adoption Plan

. . .

Product Line Action Plans

Factors Influencing Adoption

Organizational Context

- product line readiness 🟦
- barriers 🟥
- enablers ◣
- unique✚characteristics
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Adoption Support

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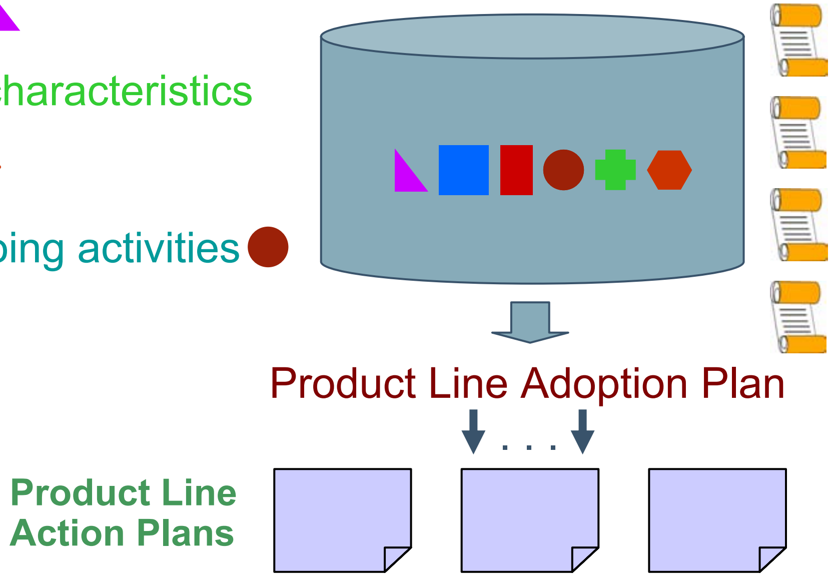
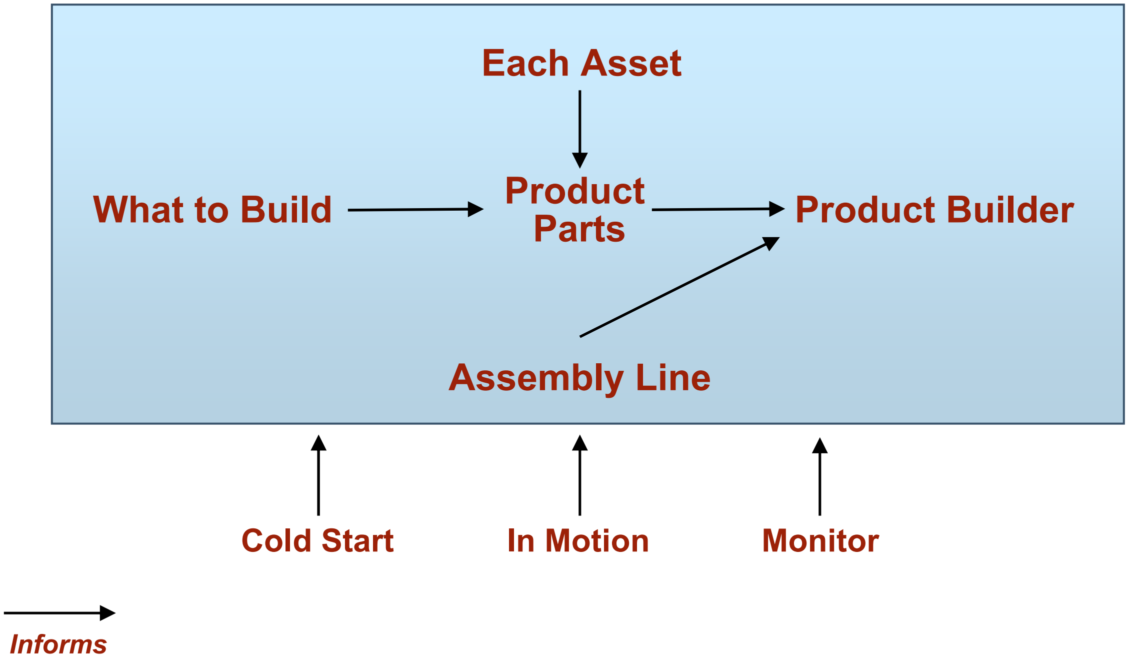


Factory Pattern Revisited



Dynamic Structure

A Variant for Adoption

The ***Factory*** pattern is already a roadmap for the entire product line organization:

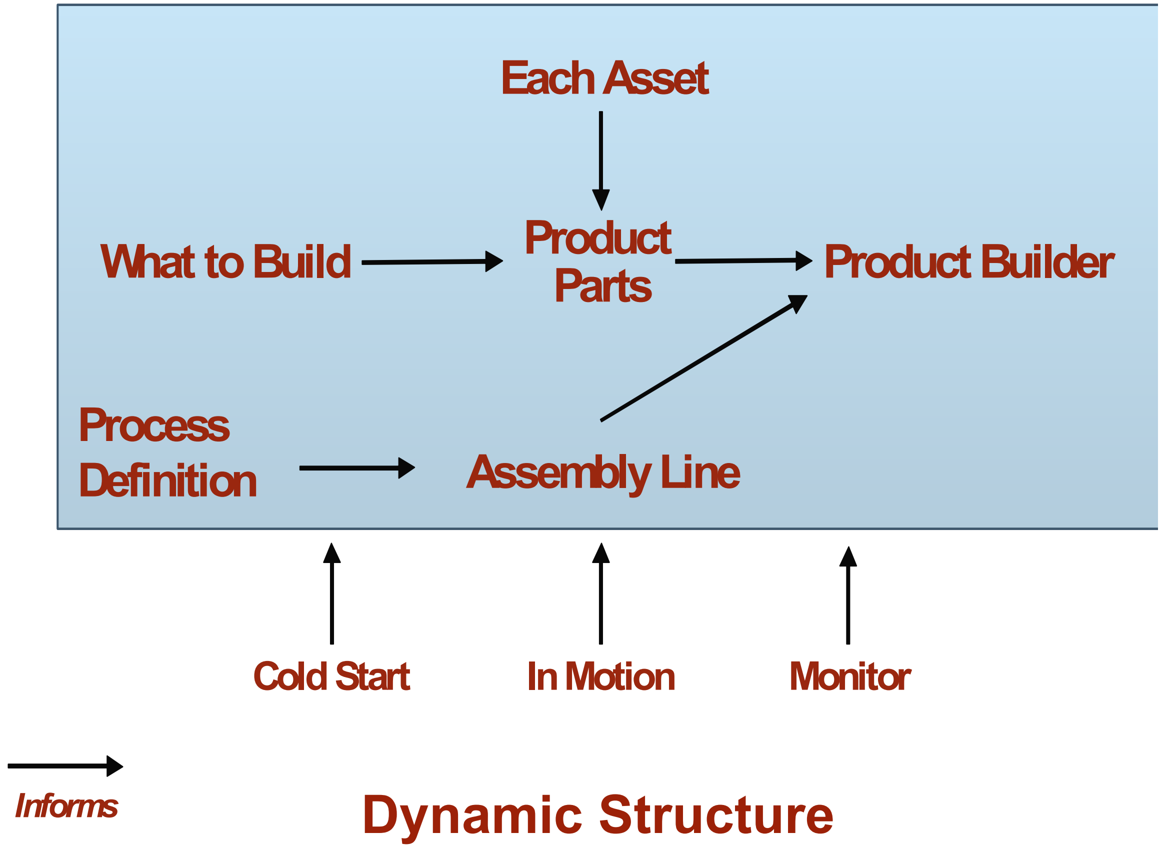
- a top-down view of the product line organization
- a blueprint for a divide-and-conquer strategy

Organizations that lack the ability to define and follow processes, even lightweight or agile ones, need to address that deficiency early in their adoption path.

Even though the “Process Definition” practice area is part of the Assembly Line pattern, it is called out separately in a variant on the ***Factory*** pattern.

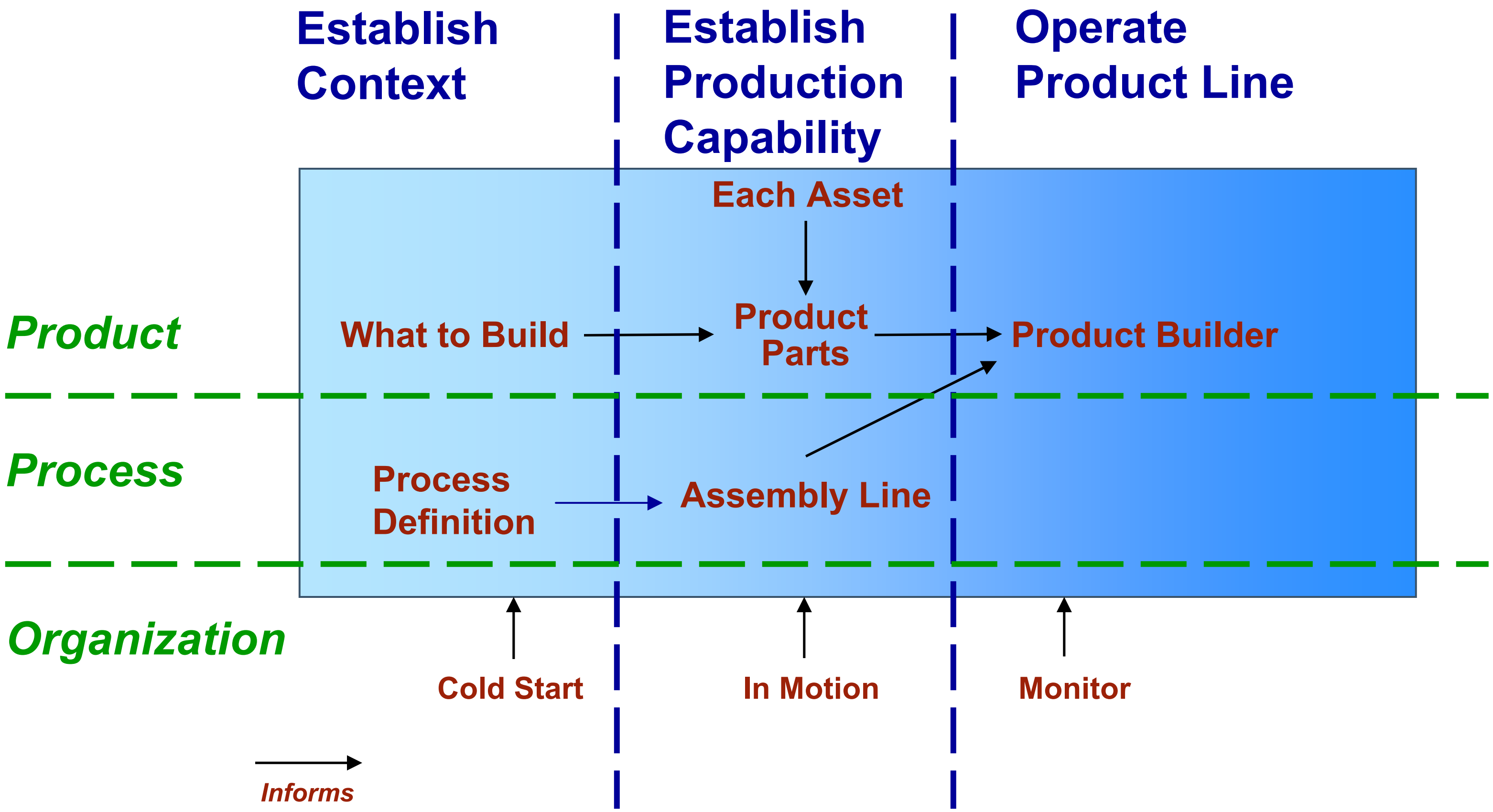
The variant is called the ***Adoption Factory*** pattern.

Adoption Factory Pattern



Dynamic Structure

Adoption Factory Pattern



Establish Context

Establish Production Capability

Operate Product Line

Product

Process

Organization

Each Asset

What to Build

Product Parts

Product Builder

Process Definition

Assembly Line

Cold Start

In Motion

Monitor

Informs

Adoption
Factory Pattern

Using the Adoption Factory Pattern- 1

To use the ***Adoption Factory*** pattern as a roadmap

- Elaborate the practice areas associated with its subpatterns.
- Plan to master these practice areas in a continuous way that begins at the phase where they first appear.

The ***Adoption Factory*** pattern applies regardless of the adoption strategy chosen – proactive, reactive, or incremental.

Associated Practice Areas

	Establish Context	Establish Production Capability	Operate Product Line
Product	Marketing Analysis Understanding Relevant Domains Technology Forecasting Building a Business Case Scoping	Requirements Engineering Architecture Definition Architecture Evaluation Mining Existing Assets Component Development COTS Utilization Software System Integration Testing	Requirements Engineering Architecture Definition Architecture Evaluation Mining Existing Assets Component Development COTS Utilization Software System Integration Testing
Process	Process Definition	Make/Buy/Mine/Commission Configuration Management Tool Support Data Collection, Metrics, Tracking Technical Planning Technical Risk Management	
Organization	Launching and Institutionalizing Funding Structuring the Organization Operations Organizational Planning Customer Interface Management Organizational Risk Management Developing an Acquisition Strategy Training	Launching and Institutionalizing Funding Structuring the Organization Operations Organizational Planning Customer Interface Management Organizational Risk Management Developing an Acquisition Strategy Training	Data Collection, Metrics and Tracking Technical Risk Management Organizational Risk Management Customer Interface Management Organizational Planning

Using the Adoption Factory Pattern - 2

You can also use the ***Adoption Factory*** pattern to gauge where in the adoption process by phase your organization is and benchmark your activities by measuring yourself against the practice areas in that phase.

- We use the ***Adoption Factory*** pattern in the analysis part of the PLTP and also in framing recommendations.
- You can use the ***Adoption Factory*** pattern as an easily understood adoption vocabulary that can be shared across an organization and marks organizational progress.

Implementing the Adoption Plan

Everyone in the product line organization is responsible for implementing the Product Line Adoption Plan.

- Each person has a stake.
- Each person has a role.
- Each person needs to contribute.

Coordination and cooperation are fundamental to successful adoption.

Roles View - 1

Another instructive view of the Adoption Factory pattern depicts the type of people who need to be involved in the product line adoption effort.

The Roles View lists the typical roles associated with each quadrant of the Phases and Focus Areas view.

This view can be used for identifying staffing needs and making assignments.

Some roles may appear in multiple phases, but the tasks those roles perform will vary with the phase.

Roles View - 2

	Establish Context Phase	Establish Production Capability Phase	Operate Product Line Phase
Product-related roles	• marketer • market analyst • domain expert • product manager • senior manager • technology scout • architect	core asset developer: • requirements engineer • architect • architecture evaluator • component developer • tester • software integrator	product developer: • requirements engineer • architect • architecture evaluator • component developer • tester • software integrator

Roles - 3

	Establish Context Phase	Establish Production Capability Phase	Operate Product Line Phase
Process - related roles	• technical manager • process owner • process group member	• technical manager • process owner • process group member • technical support • tool specialist • measurement specialist	• technical manager • process owner • process group member • technical support • tool specialist • measurement specialist

Roles - 4

	Establish Context Phase	Establish Production Capability Phase	Operate Product Line Phase
Organization-related roles	• product line manager • software manager • business unit or organization manager • product manager • acquisition expert • financial manager • human resource manager • training planner • training developer • trainer	• product line manager • software manager • business unit or organization manager • financial manager • training developer • trainer	• product line manager • product manager • business unit or organization manager • customer field representative • salesperson

Today's Talk

Introduction

Product Line Concepts

- What
- Why
- How

Conclusion

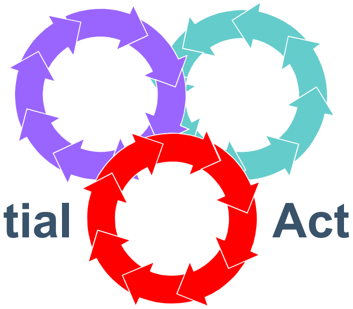
In a Nutshell

Software product lines epitomize the concept of strategic, planned reuse.

The product line concept is about more than a new technology. It is a new way of doing one’s software business.

There are essential product line activities and practices areas as well as product line patterns to make the move to product lines more manageable.

The Entire Picture



Essential Activities

Practice Areas

Software Engineering	**Technical Management**	**Organizational Management**

Guidance

Case Studies

Patterns

Probe

Adoption Factory

What’s Different About Reuse with Software Product Lines?

Business dimension

Iteration

Architecture focus

Preplanning

Process and product connection

At the Heart of Successful Product Lines

A pressing need that addresses the heart of the business

Long and deep domain experience

A legacy base from which to build

Architectural excellence

Process discipline

Management commitment

Loyalty to the product line as a single entity

The Time is Right

Rapidly maturing, increasingly sophisticated software development technologies including *object technology, component technology, and standardization of commercial middleware.*

A global realization of the *importance of architecture*

A universal recognition of the need for *process discipline*

Role models and case studies that are emerging in the literature and trade journals

Conferences, workshops, and education programs that are now including product lines in the agenda

Company and intercompany *product line initiatives*

A rising recognition of the *amazing cost/performance savings* that are possible

Evidence of Progress - 1

1. More companies are reporting software product line efforts including
   - John Deere (tractor manufacturer) went from turning out one software product in ten years to turning out two products in one year.
   - Agilent (a telecom company) is using SEI Product Line Practice Patterns as a way to successfully navigate its geographically dispersed product line effort.
   - Argon Engineering (developer of communication systems that search, identify, and capture signals): reports increased customer satisfaction, shorter development cycles, and decreased costs from its software product lines.

Evidence of Progress - 2

2. Others have product line efforts underway, including

- Caterpillar
- Delphi
- Lockheed Martin
- Northrop Grumman
- Raytheon
- Robert Bosch
- Siemens
- Visteon

Evidence of Progress - 3

3. U.S. Department of Defense product line efforts that were begun in the late 1990s are now showing quantifiable benefits:

- The Naval Undersea Warfare Center (NUWC) developed the RangeWare product line concept and asset base.
- The U. S. Army Technology Applications Program Office (TAPO) and Rockwell Collins successfully developed a software product line for the cockpit software for the Army's special operations helicopters.

Evidence of Progress - 4

4. A software product line approach is being chosen for two major U.S. Army efforts.

- Force XXI Battle Command Brigade and Below (FBCB2)
- Future Combat System (FCS)

5. Both IBM and Microsoft have gotten interested in software product lines.

- IBM included “Software Product Lines” in its 2003 Global Technology Outlook.
- Microsoft uses software product lines as the underlying motivator for its proposed software factories tool environment.

Evidence of Progress - 5

6. Mainstream U.S. conferences and magazines for software developers now feature software product lines:

- OOPSLA
- Software Development East
- ICSE
- AOSD
- *IEEE Software*
- *Software Development Times*

Evidence of Progress - 6

7. Many new technology movements have a direct relationship to software product lines and may provide additional catalysts.

- OMG’s Model-Driven Architecture (MDA)
- generative programming
- aspect-oriented development
- UML 2.0
- predictable assembly from certifiable components (PACC) from the SEI

8. SPLC 2004 was a resounding success with representation and presentations from major companies across the globe.

Remaining Challenges

Definition and implementation of appropriate variation mechanisms

Evolution of product line architectures and assets

Funding and business models to support strategic reuse decisions

Effective production plans that meet production constraints

Product line tool support

Ways to lower the initial cost of adoption

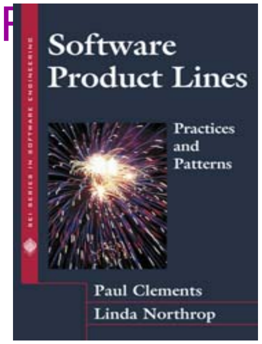
Summary of SEI Contributions

Practice integration

- A Framework for Software Product Line Practice^{SM}, Version 4.1, http://www.sei.cmu.edu/plp/framework.html

Techniques and methods

- product line analysis
- architecture definition – Attribute-Driven Design (ADD)
- architecture evaluation – Architecture Tradeoff Analysis Method^{SM} (ATAM^{SM})
- mining assets – Options Analysis for Reengineering^{SM} (OAR^{SM})
- Product Line Technical Probe^{SM} (PLTP)
- Product Line Quick Look (PLQL)
- Product line practice patterns and the Adoption F



Software Product Lines

Practices and Patterns

Paul Clements

Linda Northrop

Book

Software Product Lines: Practices and Patterns

Curriculum and Certificate Programs

- Five courses and three certificate programs

Conferences and Workshops

SPLC 1, SPLC2, SPLC 2004; Workshops 1997 - 2004

Ongoing SEI Product Line Research

Product derivation

- variability mechanisms
- production plan definition and implementation

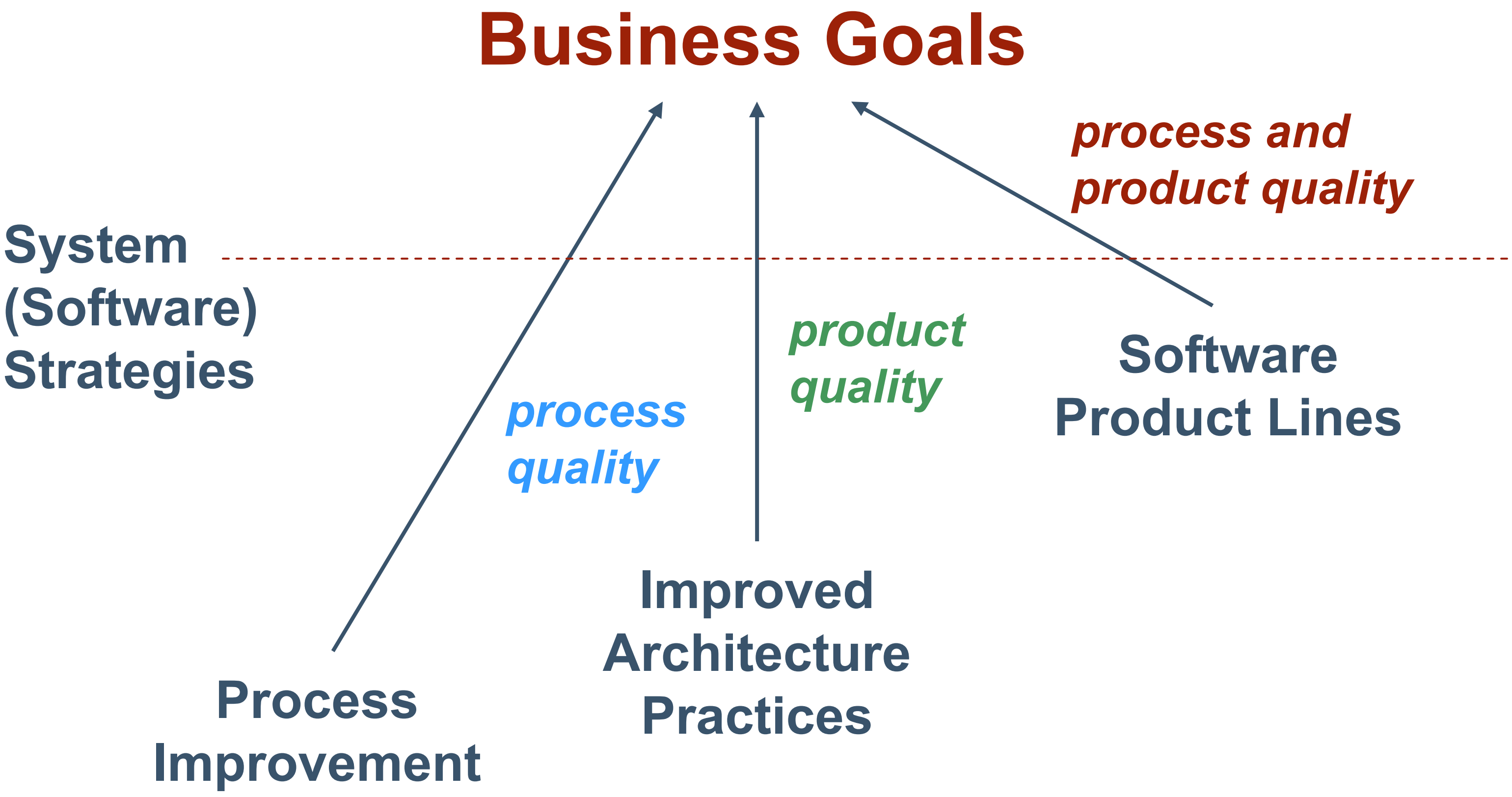
Product line sustainment

- asset evolution

Product line adoption strategies

- economic models

Software Product Line Strategy in Context



Business Goals

System (Software) Strategies

process and product quality

product quality

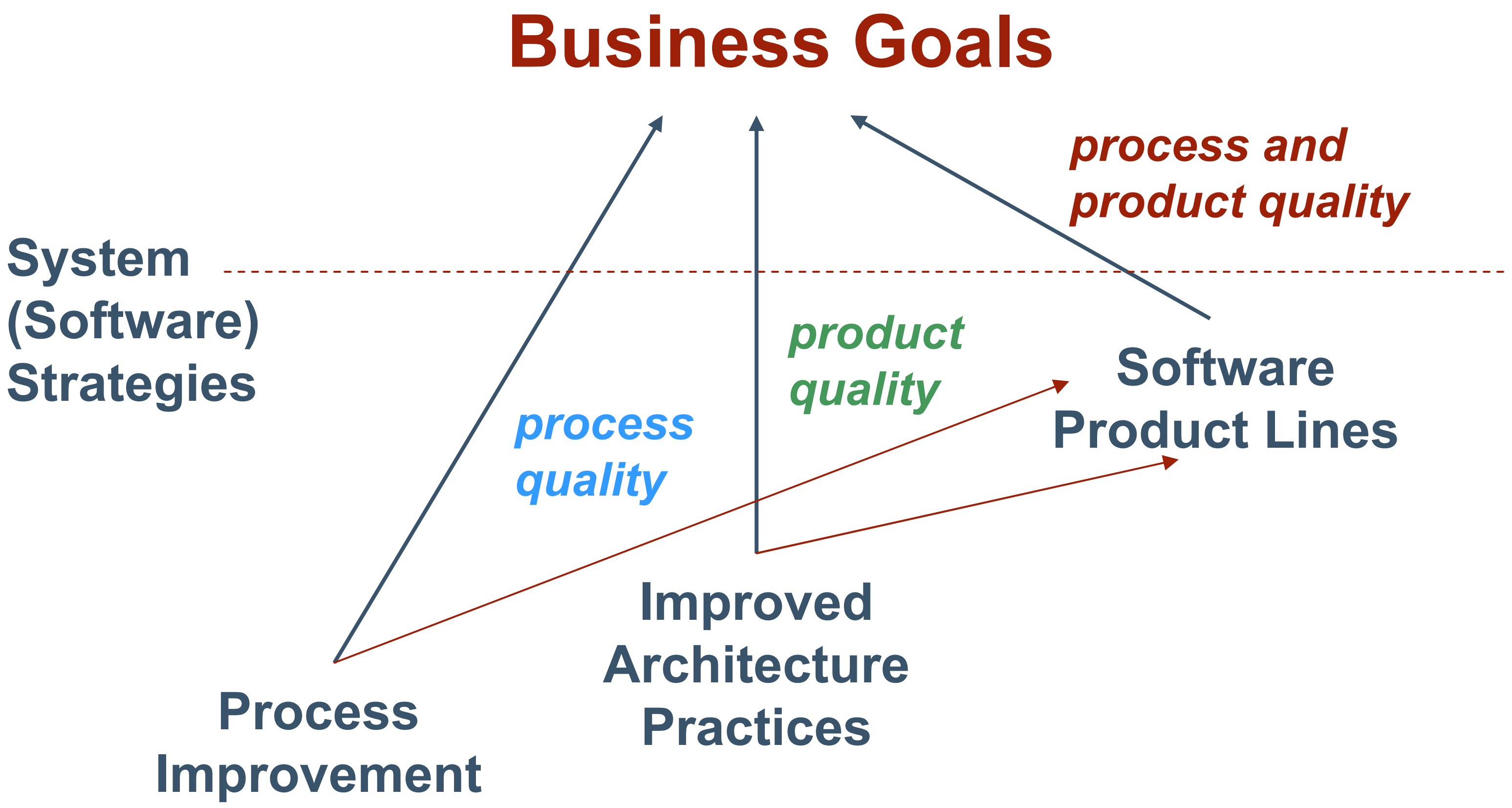
process quality

Software Product Lines

Improved Architecture Practices

Process Improvement

Software Product Line Strategy in Context



Final Word

If properly managed, the benefits of a product line approach far exceed the costs.

Strategic software reuse through a well-managed product line approach achieves business goals for:

- efficiency
- time to market
- productivity
- quality

Software product lines: Reuse that pays.

Questions – Now or Later

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